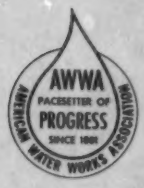
JANUARY 1958



Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 50 • NO. 1

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13 bil gal—behind
Union River Dam
for Bremerton's new supply

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Merryfield

AUTOMATIC METHODS
Appleyard, Barker

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Middleton, Rosen, Burttschell, Harlock, Dowlin

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Journal

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January 1958

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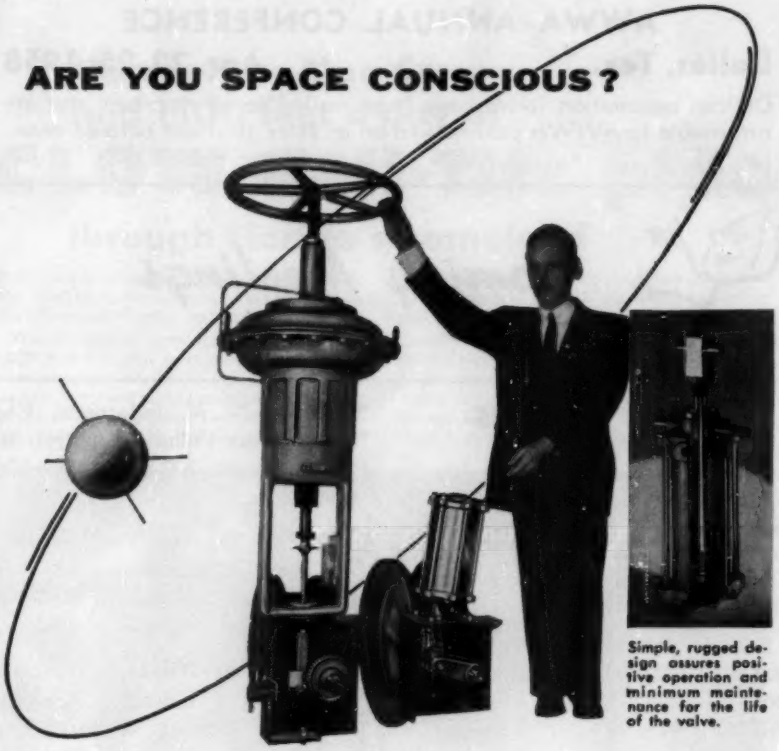

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Coming Meetings

AWWA SECTIONS

1958 Meetings

Jan. 28—New York Section Mid-winter Luncheon Meeting, Park-Sheraton Hotel, New York. Secretary, Kimball Blanchard, Riversville Rd., Greenwich, Conn.

Feb. 5–7—Indiana Section, at Sheraton-Lincoln Hotel, Indianapolis. Secretary, C. H. Canham, 3517 Manor Court, Indianapolis.

Feb. 13—New Jersey Section Winter Luncheon Meeting, at Essex House, Newark. Secretary, A. F. Pleibel, Dist. Sales Mgr., R. D. Wood Co., 683 Prospect St., Maplewood.

Mar. 12–14—Kansas Section, at Lamer Hotel, Salina. Secretary, Harry W. Badley, Representative, Neptune Meter Co., 119 W. Cloud, Salina.

Mar. 20–22—Montana Section, at Florence Hotel, Missoula. Secretary, Arthur W. Clarkson, Asst. Director, Div. of Environmental Sanitation, State Board of Health, Helena.

Mar. 23–25—Southeastern Section, at Dinkler-Plaza Hotel, Atlanta, Ga. Secretary, N. M. deJarnette, Engr., Div. of Water Pollution Control, State Dept. of Health, 309 State Office Bldg., Atlanta, Ga.

Mar. 26–28—New York Section, at Van Curler Hotel, Schenectady. Secretary, Kimball Blanchard, Riversville Rd., Greenwich, Conn.

Mar. 26–28—Illinois Section, at LaSalle Hotel, Chicago. Secretary, Dewey W. Johnson, Research Engr., Cast Iron Pipe Research Assn., 3440 Prudential Plaza, Chicago.

Apr. 16–18—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, Rupert C. Ott Jr., Neptune Meter Co., 2818—21st St., Columbus.

May 15–17—Pacific Northwest Section, at Davenport Hotel, Spokane, Wash. Secretary, Fred D. Jones, Asst. Supt., Water Dept., 306 City Hall, Spokane, Wash.

May 15–17—Arizona Section, at El Conquistador Hotel, Tucson. Secretary, Stanford I. Roth, Supervisor of Water Collections, Div. of Water & Sewers, Phoenix.

(Continued on page 8)

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Coming Meetings

(Continued from page 6)

Jun. 1–4—Canadian Section, at Royal York Hotel, Toronto, Ont. Secretary, A. E. Berry, Gen. Mgr. & Chief Engr., Ontario Water Resources Commission, Parliament Buildings, Toronto.

Jun. 25–27—Pennsylvania Section, at Hotel Lawrence, Erie. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg.

Fall 1958 Meetings

Sep. 8–10—Michigan Section, at Pantlind Hotel, Grand Rapids. Secretary, T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, DeWitt Rd., Lansing 4.

Sep. 10–12—New York Section, at Lake Placid Club, Lake Placid. Secretary, Kimball Blanchard, Riversville Rd., Greenwich, Conn.

Sep. 17–19—Ohio Section, at Statler Hotel, Cleveland. Secretary, J. H. Bass, Robert F. McGivern & Assocs., 1771—5th Ave., Columbus.

Sep. 17–19—Wisconsin Section, at Hotel Wausau, Wausau. Secretary, Harry Breimeister, Chief Utilities Engr., City Engineer's Office, City Hall, Milwaukee 2.

Sep. 22–24—Kentucky-Tennessee Section, at Peabody Hotel, Memphis, Tenn. Secretary, J. Wiley Finney Jr., Howard K. Bell, Cons. Engrs., 553 S. Limestone St., Lexington, Ky.

Sep. 24–26—North Central Section, at Hotel Duluth, Duluth, Minn. Secretary, L. N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

Sep. 28–30—Missouri Section, at Hotel Governor, Jefferson City. Secretary, Warren A. Kramer, State Office Bldg., Jefferson City.

Oct. 15–17—Iowa Section, at Fort Des Moines Hotel, Des Moines. Secretary, J. J. Hail, Supt., Water Dept., City Hall, Dubuque.

Oct. 23–24—West Virginia Section, at Daniel Boone Hotel, Charleston. Secretary, Hugh W. Hetzer, Engr., Design & Construction Dept., Union Carbide Chemicals Co., Box 8361, South Charleston 3.

Oct. 23–25—New Jersey Section, at Hotel Madison, Atlantic City. Secretary, A. F. Pleibel, Dist. Sales Mgr., R. D. Wood Co., 683 Prospect St., Maplewood.

Oct. 28–31—California Section, at Ambassador Hotel, Los Angeles. Secretary, Roy E. Dodson Jr., Supt. of Production, Water Dept., Balboa Park, San Diego.

Oct. 29–31—Chesapeake Section, Wilmington, Del. (tentative). Secretary, Carl J. Lauter, 6955—33rd St., N.W., Washington 15, D.C.

Nov. 5–7—Virginia Section, at Jefferson Hotel, Richmond. Secretary, J. P. Kavanagh, Dist. Mgr., Wallace & Tiernan Inc., 213 Carlton Terrace Bldg., Roanoke.

Nov. 10–12—North Carolina Section, at O. Henry Hotel, Greensboro. Secretary, D. Y. Brannock, Supt., Water & Sewage Plants, Burlington.

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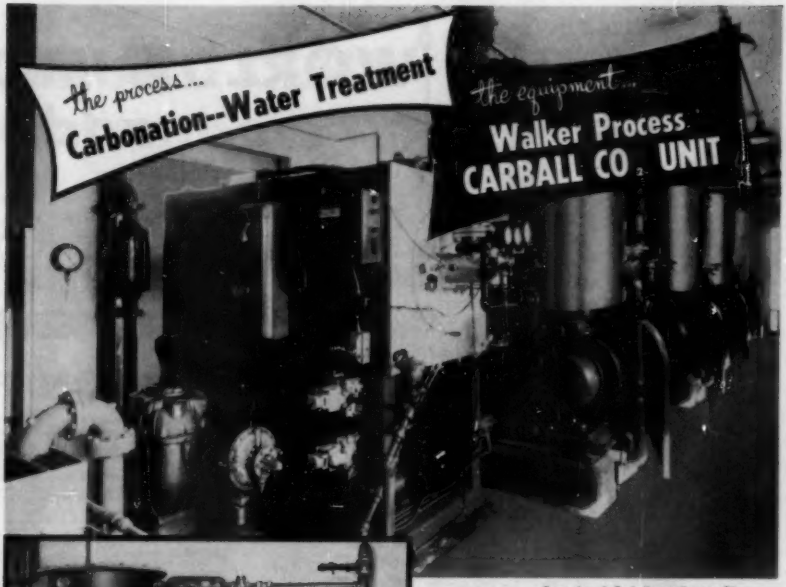

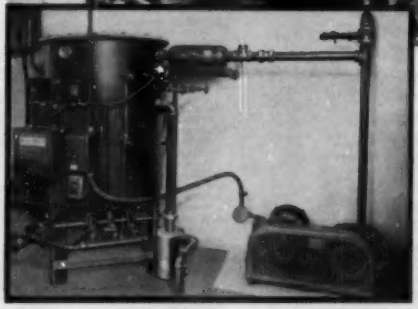

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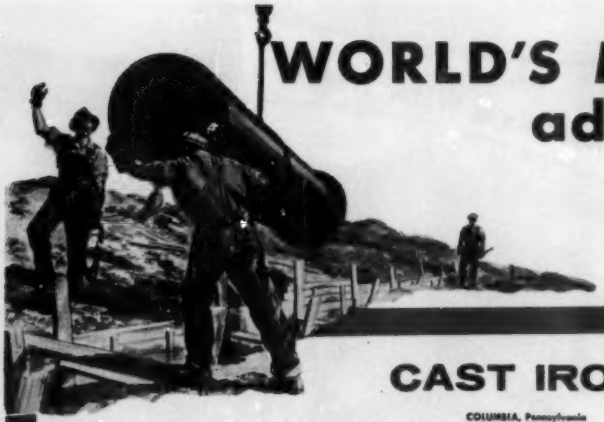

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ALBANY, New York
Dept. of Water and Water Supply
ALBANY, New York
Niagara Mohawk Power Corp. (Gas)
ALEXANDRIA, Virginia
Alexandria Water Company
ALLENTOWN, Pennsylvania
Bureau of Water
*ALTON, Illinois
Union Electric Company, Gas Division
ATLANTA, Georgia
Atlanta Gas Light Company
BALTIMORE, Maryland
Bureau of Water, Dept. of Public Works
BALTIMORE, Maryland
Baltimore Gas and Electric Company
*BANGOR, Maine
Citizens Utilities Company, Gas District
*BETHLEHEM, Pennsylvania
The United Gas Improvement Company
BOSTON, Massachusetts
Public Works Dept., Water Division
BOSTON, Massachusetts
Boston Consolidated Gas Co
BOUND BROOK, New Jersey
Public Service Electric & Gas Co
BRIDGEPORT, Connecticut
Bridgeport Gas Light Company
BUFFALO, New York
Dept. of Public Works, Div. of Water
*CAMBRIDGE, Massachusetts
Cambridge Water Board
*CARLISLE, Pennsylvania
The United Gas Improvement Co., Gas Division
*CATASAUQUA, Pennsylvania
The United Gas Improvement Company
*CHAMBERSBURG, Pennsylvania
Borough of Chambersburg, Gas Department
CHARLESTON, South Carolina
South Carolina Electric & Gas Co.
CHICAGO, Illinois
Peoples Gas Light & Coke Company
CHICAGO, Illinois
Water Works Department
CINCINNATI, Ohio
Cincinnati Gas & Electric Co.
COLUMBIA, Pennsylvania
Columbia Water Company
DETROIT, Michigan
Board of Water Commissioners
DETROIT, Michigan
Michigan Consolidated Gas Co.
ELIZABETH, New Jersey
Elizabethtown Consolidated Gas Co.
EVANSVILLE, Indiana
Southern Indiana Gas & Electric Co.
FALL RIVER, Massachusetts
Fall River Gas Works Company
FREDERICK, Maryland
City of Frederick Water Dept.
FREDERICK, Maryland
Frederick Gas Company, Inc.
CITY OF FREDERICKSBURG, Virginia
Gas Department
*HAGERSTOWN, Maryland
Hagerstown Gas Company
HALIFAX, Nova Scotia
Public Serv. Co., Public Water Supply
*HARRISBURG, Pennsylvania
The United Gas Improvement Co., Harrisburg Gas Div.
HARTFORD, Connecticut
The Hartford Gas Company
HARTFORD, Connecticut
Water Bureau, Metropolitan District
HUNTSVILLE, Alabama
Municipal Water Works
INDIANAPOLIS, Indiana
Citizens Gas & Coke Utility
KNOXVILLE, Tennessee
Knoxville Utilities Board (Gas)
*LAMBERTVILLE, New Jersey
City Gas Company
LANCASTER, Pennsylvania
Bureau of Water
LOUISVILLE, Kentucky
Louisville Gas & Electric Co.
LYNCHBURG, Virginia
City of Lynchburg Water Dept.
MADISON, Indiana
Natural Gas Service, Inc.
MEDIA, Pennsylvania
Philadelphia Electric Company Gas Dept.
MINERSVILLE, Pennsylvania
Municipal Authority, Borough of Minersville
MOBILE, Alabama
Mobile Gas Service Corp.

CAST IRON PIPE

UNUSUAL CLUB new members

The Cast Iron Pipe Century Club . . . Membership in this distinguished Club is restricted to water and gas supply systems still serving their communities through cast iron mains laid a hundred years ago . . . and more!

The Club's unique Honorary Certificate is earned only through performance. It is a tribute to the service supplied by these companies and to the carrier that enabled them to earn it . . . world's most dependable pipe . . . cast iron!

CENTURY CLUB

MOBILE, Alabama
Mobile Water Works Company

MONTREAL, Quebec
Quebec Hydro-Electric Commission

MONTREAL, Quebec
Public Works Dept., Water-Works & Sewerage Division

*MOUNT HOLLY, New Jersey
The Mount Holly Water Company

*NANTUCKET, Massachusetts
Nantucket Gas & Electric Company

NASHUA, New Hampshire
Pennichuck Water Works

NASHVILLE, Tennessee
Waterworks Department

NEW BRUNSWICK, New Jersey
Public Service Electric & Gas Co.

*NEWBURGH, New York
Water Department

NEW HAVEN, Connecticut
New Haven Gas Company

NEW ORLEANS, Louisiana
New Orleans Public Service Inc. (Gas)

NEWARK, New Jersey
Public Service Electric & Gas Co.

*NEW YORK, New York
Consolidated Edison Company of N. Y., Inc., Gas Div.

NEW YORK, New York
Dept. of Water, Gas & Electricity

NORRISTOWN, Pennsylvania
Philadelphia Electric Co., Gas Dept.

*NORWICH, Connecticut
Department of Public Works, Gas Division

*OTTAWA, Ontario
Ottawa Gas

PAINESVILLE, Ohio
City of Painesville, Gas Distribution Dept.

PEORIA, Illinois
Central Illinois Light Company

PHILADELPHIA, Pennsylvania
Dept. of Public Works, Bureau of Water

PHILADELPHIA, Pennsylvania
Philadelphia Gas Works Co.

PITTSBURGH, Pennsylvania
Bureau of Water Dept. of Public Works

PLYMOUTH, Massachusetts
Plymouth Gas Light Company

POTTSVILLE, Pennsylvania
Pottsville Water Company

*POUGHKEEPSIE, New York
Central Hudson Gas & Electric Corporation, Gas Division

PROVIDENCE, Rhode Island
Providence Gas Company

QUEBEC, Quebec
Quebec Power Co., Gas Division

READING, Pennsylvania
Bureau of Water

RICHMOND, Virginia
Department of Public Utilities (Gas)

RICHMOND, Virginia
Dept. of Public Utilities (Water)

ROCHESTER, New York
Rochester Gas & Electric Corp.

SACRAMENTO, California
Division of Water & Sewers

ST. JOHN, New Brunswick
Water & Sewerage Department

ST. LOUIS, Missouri
Dept. of Public Utilities, Water Div.

SALEM, Massachusetts
North Shore Gas Company

*SANDUSKY, Ohio
The Ohio Fuel Gas Company

SAVANNAH, Georgia
South Atlantic Gas Company

SPRINGFIELD, Illinois
Central Illinois Light Company

SYRACUSE, New York
Water Div., Dept. of Engineering

TORONTO, Ontario
The Consumer's Gas Co. of Toronto

TROY, New York
Department of Public Works

UTICA, New York
City of Utica, Board of Water Supply

*WASHINGTON, D. C.
Washington Gas Light Company

WHEELING, West Virginia
City of Wheeling Water Department

WILLIAMSPORT, Pennsylvania
Williamsport Municipal Water Authority

WILMINGTON, Delaware
Wilmington Water Department

WINCHESTER, Virginia
Water Department

WINSTON-SALEM, North Carolina
Water Department

YORK, Pennsylvania
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ZANESVILLE, Ohio
Water Department

*New members in 1957

RESEARCH ASSOCIATION
THOMAS F. WOLFE, MANAGING DIRECTOR
SUITE 3440, PRUDENTIAL PLAZA, CHICAGO 1, ILLINOIS

Select the BEST for SURE Operation and LOWER Maintenance Cost

ROCKWELL — "AWWA"
Butterfly Valves

- Drop-Tight Shutoff
- Minimum Restriction to Flow
- Minimum Pressure Drop
- Non-Clogging
- Better Control—Manual or Automatic
- Compact—Lighter Weight
- Reduced Installation Space
- Lowest Installed Cost
- Less Maintenance

Write for Bulletin 574

Made in all standard sizes of cast iron, cast steel, stainless steel, bronze and other alloys; natural or synthetic rubber seat with clamping segments, or spool type rubber liner extending over flange faces. Compact, rugged construction. Manual or automatic control for convenient, easy operation.

ROCKWELL "D-D"
Diaphragm Valves

For controlled throttling or cut-off on corrosive or abrasive fluids, or water. Disc for positive closure, diaphragm for positive sealing. No packing gland to leak. Oversized ports; high capacity; low pressure drop. Lower handwheel torque and fewer turns to close. Lower thrust for automatic operation. Body of any metal or with any lining; disc and diaphragm of rubber or plastic. Sizes—½" to 6". Write for Bulletin.

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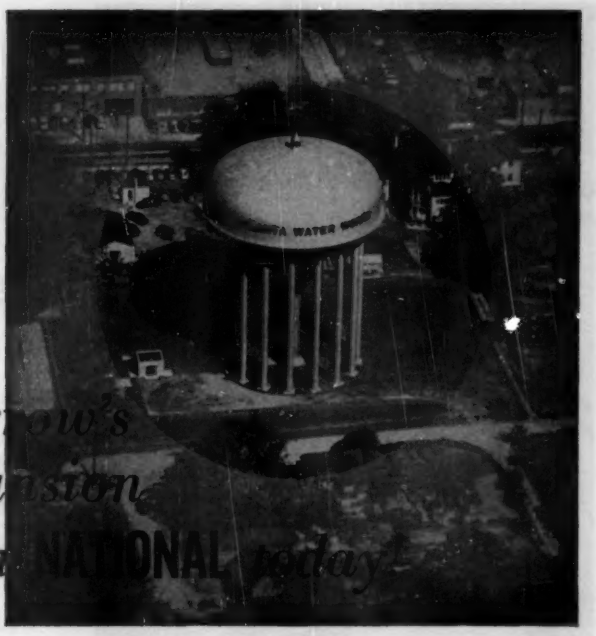

For tomorrow's expansion call in NATIONAL today!

Like Atlanta, Ga., *you* too can meet tomorrow's increased water demands with *clean water mains.* When the coefficient of sections of Atlanta's 45 year old main dropped to a low of 44, Waterworks General Manager, Paul Weir ordered National cleaning. Results were outstanding. Water pressure and capacity doubled, giving better fire protection and higher water pressure to outlying sections.

Do as other leading cities have done—let *National* cleaning provide for tomorrow's expansion without capital expenditure today! We can prove that National cleaning is an investment—not an expense.

Write us today!

NATIONAL WATER MAIN CLEANING COMPANY

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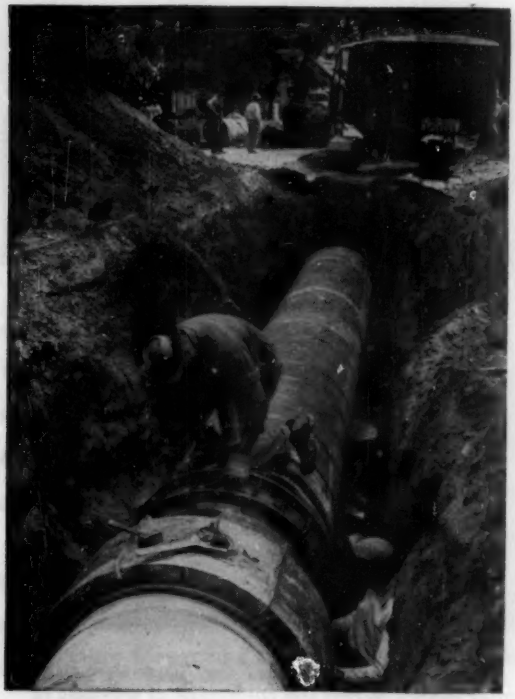
ATLANTA 3, GA., 333 Candler Building ● BERKELEY, CALIF., 920 Grayson Street ● BOSTON 15, MASS., 115 Peterboro Street ● CHARLOTTE, N. C., 533 Hollis Road ● CHICAGO, ILL., 8 So. Dearborn Street ● DECATUR, GA., P. O. Box 385 ● EL MONTE, CALIF., 2024 Merced Avenue ● FLANDEAU, S. D., 315 N. Crescent Street ● KANSAS CITY, MO., 3707 Madison Avenue ● MINNEAPOLIS, MINN., 200 Lumber Exchange Building ● RICHMOND 21, VA., 2910 W. Clay Street ● SALT LAKE CITY, UTAH, 502 West 3rd Street ● SIGNAL MOUNTAIN, TENN., 204 Slayton Street ● VILLA PARK, ILL., 424 S. Yale Avenue ● MONTREAL, CANADA, 7445 Chester Avenue ● WINNIPEG, MANITOBA, 576 Wall Street ● BOGOTA, COLOMBIA, Apartado de Correos #5 ● SAN JUAN 10, PUERTO RICO, Manquinaria, Apartado 2184 ● LIMA, PERU, Bolivar 441-A, Marafi ● CARACAS, VENEZUELA, Apartado 561 ● OSLO, NORWAY, Radhusgaten 30.



DELIVERING
WATER CHEAPER

Engineered and built by the city of Syracuse, N. Y., this 38.7" Dresser-Coupled steel water supply line was backfilled immediately after each 30' length was joined, getting streets back to work fast, practically eliminating the problem of trench cave-ins.

Too Quick for Cave-ins!

Dresser-Coupled steel line permits backfilling without delay

Whenever conditions demand immediate backfill, steel pipe and Dresser Couplings make it surer, safer to comply.

On this Syracuse water supply job, for example, the cave-in hazard of unstable sandy loam was heightened by heavy traffic nearby. The problem was solved by immediate backfilling, a standard Syracuse practice on all Dresser-Coupled water lines, where leaving trenches open for line test during construction is considered unnecessary.

Proved in thousands of installations, these factory-tested couplings give 100% bottle-tight joints every time. Their resilient rubber gaskets absorb vibration and pipe-transmitted stresses . . . assure no-leak safety for the life of the line.

Dresser Couplings and steel pipe provide trouble-free lines that always *deliver water cheaper.*

Wherever water flows, steel pipes it best. Always put steel pipe and Dresser Couplings in your specifications. Dresser Manufacturing Division, Bradford, Pa. Sales offices in: New York, Philadelphia, Chicago, South San Francisco, Houston, Denver, Toronto, Calgary.

ONE OF THE DRESSER INDUSTRIES

FROM
THE FILES OF
DR. CENTRILINE

"Hmmm ... a bad case of corrosion"

CASE #7841

PATIENT:	8 Miles of 16" and 12" Cast Iron Water Supply Lines in Abington-Rockland (Mass.) Water District.
SYMPTOMS:	Lack of water and pressure during periods of high demand requiring restrictions in the summertime.
DIAGNOSIS:	Poor circulation due to regrowth of tuberculation after cleaning. Available water could not be delivered to consumers.
TREATMENT:	The lines were cleaned and cement lined in place without interrupting service to consumers. In less than 8 weeks the entire job was completed.
RESULTS:	Patient now sound and healthy; pipe capacity permanently doubled, no further summer restrictions, future maintenance costs were eliminated.

If your lines also show signs of suffering from corrosion, leakage or tuberculation, investigate the Centriline Process. Cleaning and cement lining in place has been a successful remedy for over 1,000 miles of water supply pipelines. Centriline hasn't lost a patient yet.

CENTRILINE CORPORATION

A subsidiary of the Raymond Concrete Pile Company

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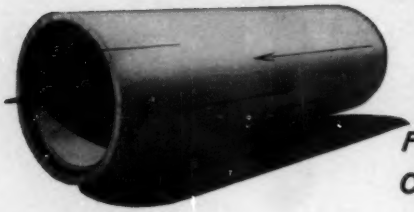
Branch Offices in Principal Cities of the United States, Canada, and Latin America.

SMOOTH FLOW KEEPS COSTS LOW!



YOUR CITY SAVES ON MAINTENANCE COSTS FOR YEARS TO COME WITH CONCRETE PRESSURE PIPE!

Because of its great resistance to corrosion and tuberculation, dependable Concrete Pressure Pipe gives your city extra years of trouble-free service, gives impressive dollar savings on maintenance costs throughout its unusually long life span.

You save money for your city—from the trench to the pump—when you choose Concrete Pressure Pipe, with easy-fitting Rubber Gasket Joints. Specify it and get these "4 big savings" built into every piece of low-cost, long-lasting Concrete Pressure Pipe.

1. **YOU SAVE ON FIRST COSTS—The variety of designs available in Concrete Pressure Pipe makes it possible to choose the most economical design which will serve with maximum efficiency under the specified operating conditions required of the line.**
2. **YOU SAVE ON INSTALLATION COSTS—With Rubber Gasket Joints, there's no caulking, bolting or welding needed. You can have minimum width trenches and immediate backfilling.**
3. **YOU SAVE ON MAINTENANCE COSTS—Durable Concrete Pressure Pipe has an experience record of almost complete freedom from corrosion and tuberculation. Elastic design virtually eliminates possibility of bursting—even under conditions of extreme surge and water hammer.**
4. **YOU SAVE ON OPERATING COSTS—Freedom from tuberculation insures a high sustained carrying capacity. No spiralling pumping costs and no reduced pressures.**

In the main—the trend is to concrete!

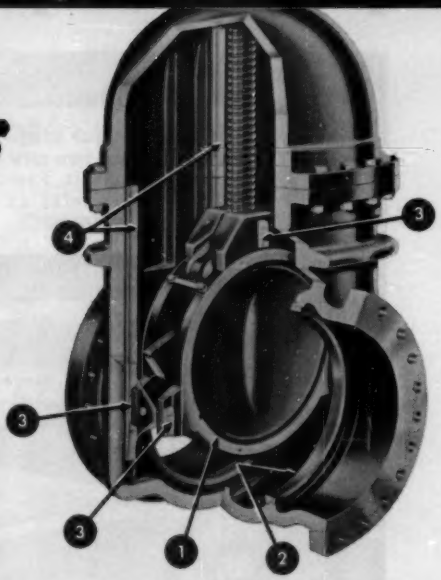
AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION

228 North LaSalle Street • Chicago 1, Illinois

SMITH THROTTLE CONSTRUCTION VALVES

ELIMINATES
disc tilting and chatter

REDUCES
wear of disc & seat ring faces



Smith Square Bottom Throttle Construction Valves have all of the time-proven design and construction refinements of standard Smith Gate and Tapping Valves and are recommended for severe service applications such as throttling in a partly open position, daily or frequent operation against high unbalanced pressure, high velocity or installation in a flat position in vertical piping.

The design features consisting of disc shoes and body tracks mechanically lift and hold the disc ring face (1) out of contact with the seat ring face (2) at all points of disc travel with the exception of the fully closed position.

Throttle construction valve discs are provided with three non-ferrous metal shoes (3), precision-machined and jig located. Valve bodies are provided with three non-ferrous metal machined tracks (4). The three disc shoes register with the three body tracks and each shoe is in contact with a track while the valve is unseated and in any partially open position. The bottom section of each track is bevelled to insure that the shoes will not bear on the tracks when the valve is fully closed.

This construction prevents damage to and uneven disc and seat face wear and assures long service life under severe operating conditions.

Single throttle construction is used when the flow is not subject to reversal. Double throttle construction when the flow is subject to reversal.

58

FIRE HYDRANTS VALVES SINCE 1858

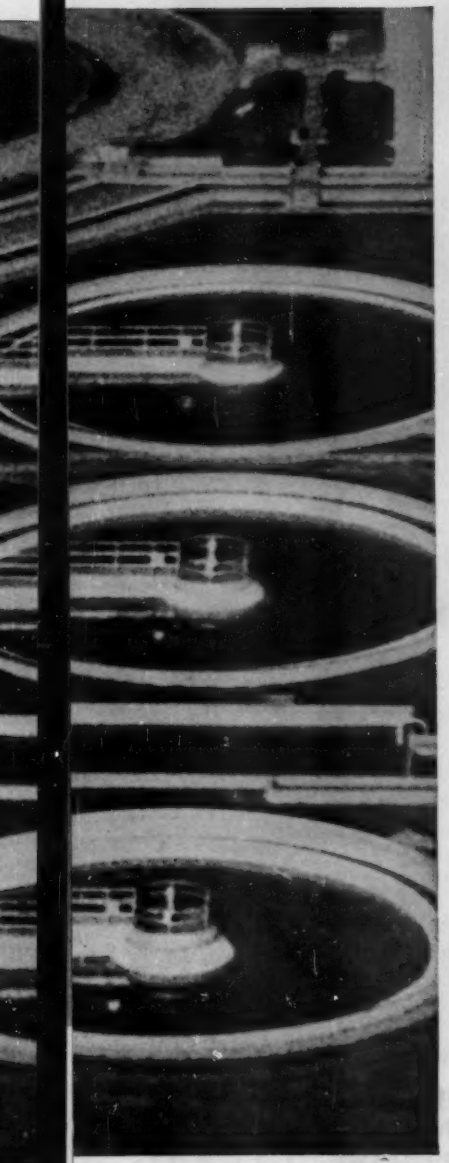
THE A.P. SMITH MFG. CO.
EAST ORANGE, NEW JERSEY

20-year record proves efficiency

Enlarged aerial snapshot shows the two new 10-mgd Permutit Precipitators (at left) at Springfield, Illinois.

- The original Spaulding Precipitators built in 1936. Engineers for both original plant and extension: Burns & McDonnell Eng. Co., Kansas City, Mo.

# of upflow "Precipitators"



In 1936, Springfield built three short-detention, upflow softening-coagulation units newly developed by Charles H. Spaulding.

From the start, the Spaulding-designed units showed high flow rates – many times faster than the old basin system, a uniform quality effluent that doubled filter capacity, a low chemical cost and a low maintenance cost.

When Springfield's recent expansion program called for doubling its water-treating capacity, city engineers had almost 20 years of proven performance to guide them, a longer performance record than is available with any other type of upflow, sludge-blanket unit. That's why Permutit Precipitators based on Spaulding designs were chosen for the new units.

For complete details on any type of water conditioning equipment, write: The Permutit Company, Dept. JA-1, 50 W. 44th St., New York 36, or Permutit Company of Canada, Ltd., Toronto 1, Ont.

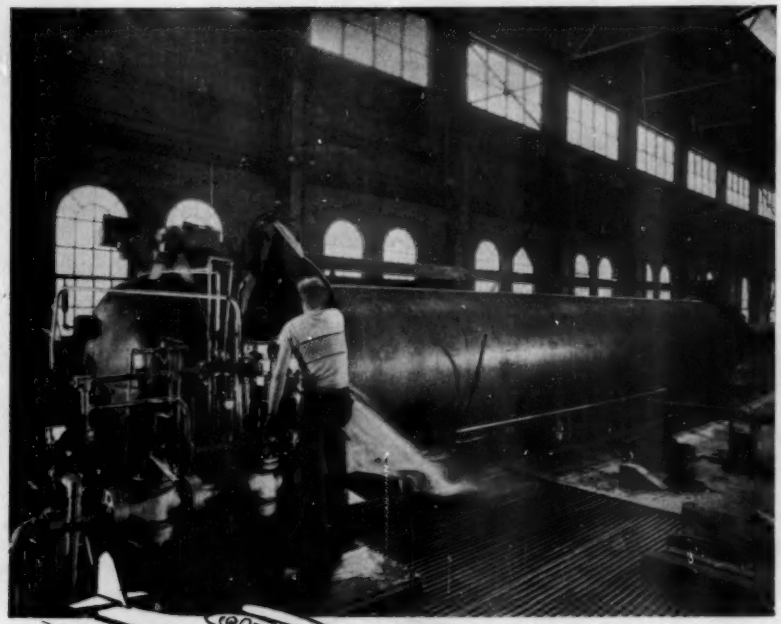
PERMUTIT.

rhymes with "compute it"

A DIVISION OF PFAUDLER PERMUTIT INC.

Water Conditioning

Ion Exchange • Industrial Waste Treatment



STEEL PIPE
HAS ITS TEST PILOTS, TOO!

Like the more glamorous aviation test pilot, the steel pipe tester plays a vital role in the story of safety. His job demands the greatest caution and concern to assure your water pipe meeting the highest standards of safety, strength and performance.

This specialist hydrostatically tests *every* length of steel pipe to at least twice its required working pressure . . . to guarantee you maximum protection against breakage and leakage. And steel pipe is the *only* water pipe that undergoes this rigid individual testing process.

When you need a pipe that you know in advance will pass all the tests of stress and time—you're smart to specify STEEL pipe.

"WHEREVER WATER FLOWS—STEEL PIPES IT BEST"

STEEL PLATE FABRICATORS ASSOCIATION

79 W. MONROE ST., CHICAGO 3, ILL.

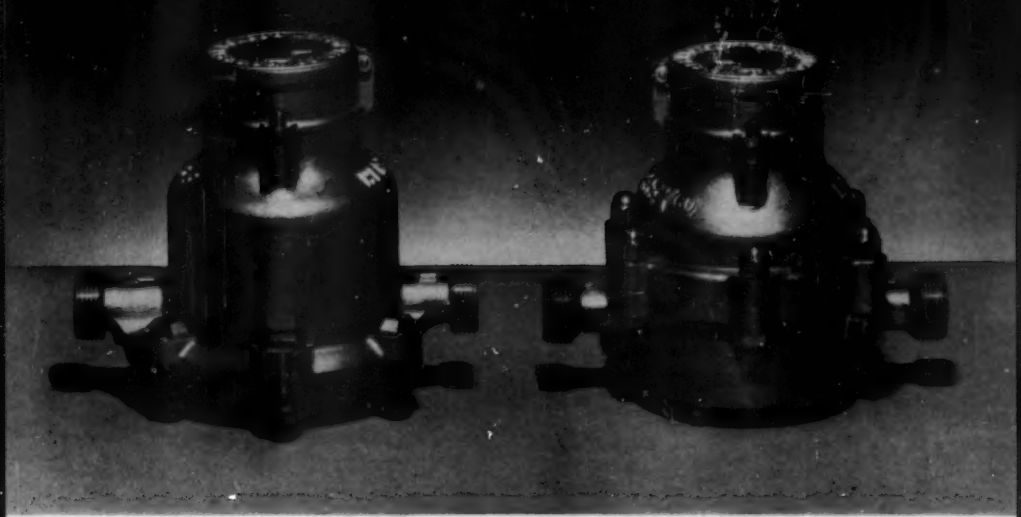
HERSEY

WATER METERS

are outstanding for —

(1.) Lowest maintenance cost year after year.

(2.) Accurate registration that insures full return for all water used.



Contact our nearest Branch for full details

HERSEY MANUFACTURING COMPANY

DEDHAM, MASS.

BRANCH OFFICES: NEW YORK — PORTLAND, ORE. — PHILADELPHIA — ATLANTA — DALLAS
CHICAGO — SAN FRANCISCO — LOS ANGELES

At last report there were 24 diatomite filtration plants serving municipalities in the United States—20 of them filtering the communities' drinking water. Let's summarize the reports of these 20.

SIZE OF COMMUNITY Population range from 450 to 10,000.

LENGTH OF SERVICE Plant installations date from 1949 (2) to 1956 (2). The greatest number went into service in 1952, 1954 and 1955—long enough to allow the accumulation of reliable service data.

HEALTH DEPT. APPROVAL Yes, in all cases except for one community in Oregon where the installation is classed as experimental.

WATER SOURCES Small streams, wells, rivers (including some regarded as 'flashy'), lakes, an aqueduct and a pipeline.

RAW WATER IMPURITIES Turbidity, principally, although plankton, algae, iron and color are also mentioned.

RESULTS Good to very good—6. Satisfactory—11. Fairly good—1. Problems—1 (due to seasonal concentrations of organisms).

NOTE: The fact that 12 of these 20 communities number less than 1,000 population is convincing evidence that highly-skilled personnel are *not* required for the satisfactory operation of a diatomite filtration plant, since communities of this size can seldom afford a high-salaried operator on a single-purpose job which can be handled in an hour or so a day.

Dicalite Bulletin BW-13, newly revised, contains interesting new information on diatomite filtration of municipal water supply. Write for your copy.

Dependable GLC GREAT LAKES Dicalite® DIATOMACEOUS MATERIALS

DICALITE DEPT. Great Lakes Carbon Corp., 612 S. Flower St., Los Angeles 17, Calif.

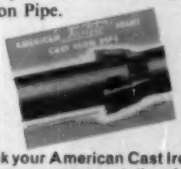
AMERICAN Fastite® JOINT* CAST IRON PIPE

Now—another important AMERICAN development—a superior *double-sealing* single gasket type joint—American Fastite! This new *field-tested* joint brings installation time and labor costs to new lows! The exclusive *double-sealing*, dual-density rubber gasket and the scientifically designed gasket recesses permit faster, more simple installation—allow liberal deflections—provide positive sealing under low or high pressures! Get full information about the American Fastite joint today—discover for yourself the advantages available only with American Fastite Joint* Cast Iron Pipe.

EXCLUSIVE DOUBLE-SEALING, DUAL-DENSITY RUBBER GASKET!

- Hard rubber end provides a strong shoulder for self-centering and locking—a permanent seal against cold flow under pressure, fully protected against deterioration.
- Softer large end for positive compression, liquid-tight sealing and easy assembly.

Tests prove either hard or soft rubber section alone provides a positive seal.



Ask your American Cast Iron Pipe Company representative about the unique advantages of this superior double-sealing single gasket joint—American Fastite—or write today for a free descriptive brochure.

**Patent applied for—Underwriters Laboratories, Inc. approved.*

SALES OFFICES New York City • Chicago • Kansas City • Minneapolis • Dallas • Denver Orlando • Los Angeles • Pittsburgh • San Francisco • Cleveland

AMERICAN CAST IRON PIPE CO.
BIRMINGHAM 2, ALABAMA

TC TENNESSEE CORPORATION

1 Manganese and Silical removal

Increased filter runs 2

3 Coagulation over wide pH ranges

4 Rapid floc formation

5 Turbidity removal

6 Economy

7 Color removal

8 Excellent taste and odor control

9 Bacteria removal

10 Ease of Operation

Ferri-Floc TC FERRIC SULFATE

The Superior **COAGULANT**

With The Plus **FACTORS—**

Ferri-Floc gives smoother, more efficient and trouble free operation. Whatever your particular water treatment problem may be, you can depend on Ferri-Floc doing a superior job and doing it efficiently and economically—Ferri-Floc is a free flowing granular salt which can be fed with few modifications through any standard dry feed equipment. It is only mildly hygroscopic, thereby permitting easy handling as well as storage in closed hoppers over long periods of time.

WATER TREATMENT

Efficient coagulation of surface or well waters. Aids taste and odor control—Effective in lime soda-ash softening. Adaptable to treatment of nearly all industrial waters.

SEWAGE TREATMENT

Ferri-Floc coagulates water and wastes over wide pH ranges—it provides efficient operation regardless of rapid variations of raw sewage and is effective conditioning sludge prior to vacuum filtration or drying on sand beds.

FREE BOOKLET

Let us send you without charge, a 38 page booklet that deals specifically with all phases of coagulation—just send us a postal card.

SULFUR-DIOXIDE HIGHEST QUALITY SO_2

SULFUR-DIOXIDE is effectively used for dechlorination in water treatment and to remove objectionable odors remaining after purification.

COPPER TC SULFATE

COPPER SULFATE will control about 90% of the microorganisms normally encountered in water treatment plants more economically than any other chemical.

TENNESSEE TC CORPORATION

617-29 Grant Building, Atlanta, Georgia

Typical packaged system for water treating ready for shipment includes an H20 simplex pump, a 50-gallon polyethylene tank, suction piping, close-off and relief valves.

Milton Roy H20 Simplex Controlled Volume Pump

Controlled Volume Pumps meter chemical solutions accurately

You can depend on Milton Roy H20® Controlled Volume Pumps to meter your boiler-water treatment chemicals accurately, in addition to other mildly corrosive and non-corrosive liquids.

High metering accuracy, long service life, minimum maintenance, availability from stock, and low cost are all advantages of H20 pumps. They embody quality design features usually found only in higher priced pumps, including: self-aligning bearings . . . self-adjusting packing . . . double ball checks on suction and discharge . . . cartridge-type, easily replaceable valves . . . standard continuous flushing connections.

For your water treating jobs, Milton Roy Controlled Volume Pumps can provide the logical, economical answer to chemical metering as well as accurate flow control. Write for Bulletin 557.

Milton Roy Company, 1300 East Mermaid Lane, Philadelphia 18, Pa. *Engineering Representatives throughout the world.*

milton Roy

CHEMICAL INSTRUMENTATION SYSTEMS

CONTROLLED VOLUME PUMPS • QUANTICHEM ANALYZERS
CHEMICAL FEED SYSTEMS • ANDERS AIR AND GAS DRYERS

Add to these benefits of

Cyanamid Alum

- Maximum adsorption of suspended and colloidal impurities
- Forms floc rapidly—coagulates in wide pH range
- Uniform feed—and a purity that minimizes equipment corrosion

The extra advantages of

Cyanamid Liquid Alum

- Easy unloading—no bags—compact storage—and turn-of-the-valve handling
- Consistent concentration that permits automatic metering, accurate gauging
- Cleaner—more efficient operation—greater flexibility with less man power
- Quick pay-off on dry-to-liquid conversion because of lower costs.

. . . and let Cyanamid help you with *technical service* based on long experience with dry and liquid alum installations. *Product service* from 9 shipping points, in bags, tank cars or tank trucks.

CYANAMID

AMERICAN CYANAMID COMPANY

Heavy Chemicals Department

30 ROCKEFELLER PLAZA, NEW YORK 20, NEW YORK

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WORTHINGTON-GAMON

WATCH DOG

The meter used by thousands of municipalities in the U. S.

WATER METERS

"Watch Dog" models . . . made in standard capacities from 20 g.p.m. up: frost-proof and split case in household sizes. Disc, turbine, or compound type.

SURE TO MEET YOUR SPECIFICATIONS FOR ACCURACY, LOW MAINTENANCE, LONG LIFE.

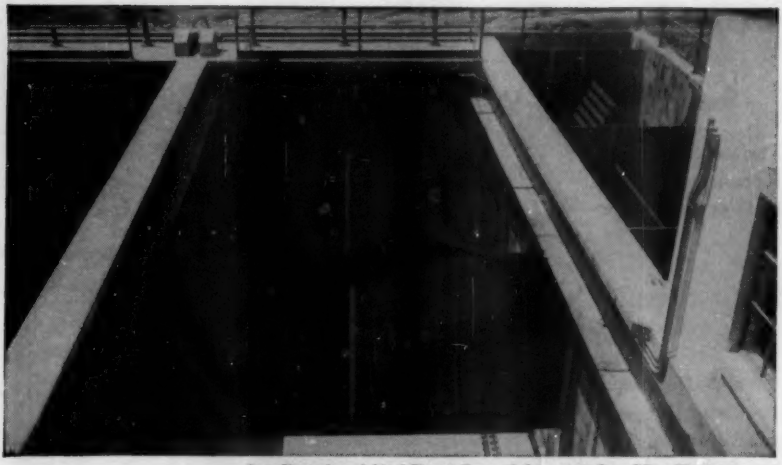
Before you invest in water meters, get acquainted with the design and performance advantages which make Worthington-Gamon Watch Dog Water Meters first choice of so many municipalities and private water companies in the United States.

WORTHINGTON-GAMON METER DIVISION

Worthington Corporation

296 SOUTH STREET, NEWARK 5, NEW JERSEY

OFFICES IN ALL PRINCIPAL CITIES



Rex Floctrol and Verti-Flo at Boro of Somerset, Pa., Filter Plant.
Consulting Engineers: Gannett, Fleming, Corddry & Carpenter, Harrisburg, Pa.
L. J. Whipperman, Plant Operator. Richard Pyle, Boro Manager.

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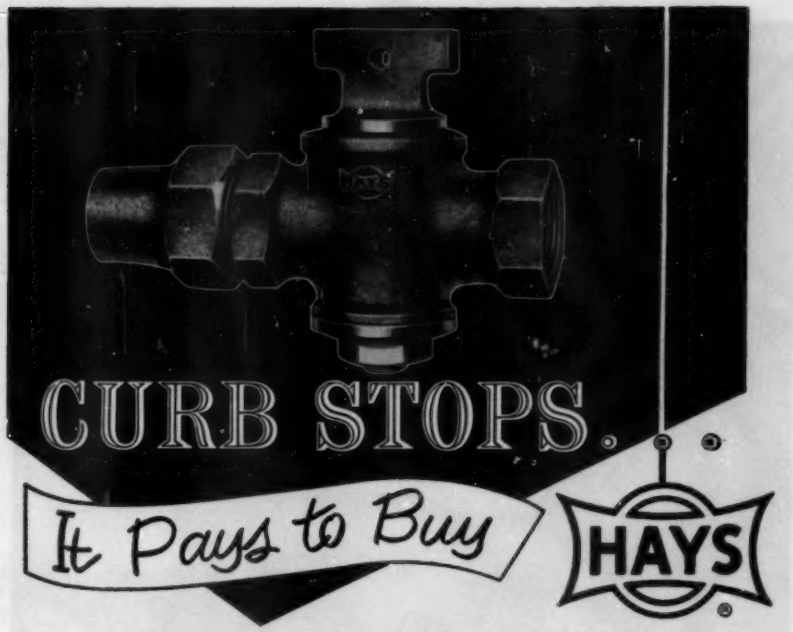

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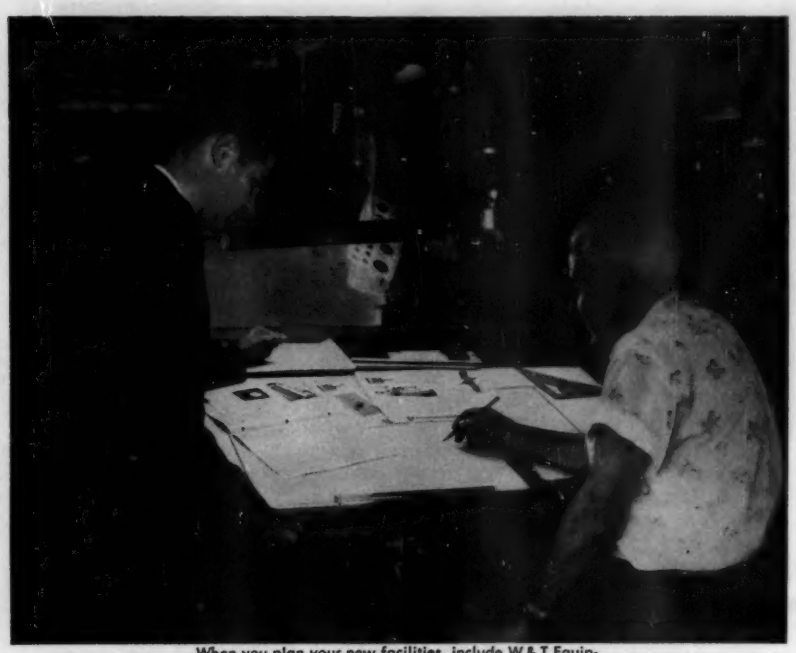

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Modernizing Our Approach to Water Utility Problems

Fred Merryfield

An appraisal of the water utility field today and tomorrow by AWWA President Fred Merryfield, Prof. of San. Eng., Oregon State College, Corvallis, Ore.

FOR more than a year it has been my privilege and pleasure to attend many AWWA section meetings as the official representative of the Association. Although during this time it has not been possible to visit all sections, I have been afforded the personal opportunity of witnessing activities, meeting members, and hearing members deliver papers in a representative group. And I feel that I owe to all members a report on my observations at these meetings.

There has been a noticeable improvement in the presentation of papers at technical meetings, including those of the Association itself, during the last 30 years. Voice amplification, projection of technical data, and air conditioning of convention halls have aided materially in communication between speaker and audience. Some improvement is still needed in the physical arrangements, as well as in the speaker's personal presentation, however great the gains already noted in that field. Many of our managers and engineers are much more at ease on the platform than formerly. The summarizing of written papers rather than their reading in full detail is becoming more common. This method adds considerably to the interest of the audience.

About a third of the speeches given today at the section meetings refer to items unknown or unrecognized 15 years ago. There is also a noticeable increase in attention to management matters. Many of the new items, both technical and administrative, indicate a healthy intellectual curiosity on the part of our members in meeting conflicting and complex new problems. This is not new, of course, as AWWA has done much pioneering in the water supply field, but even if the condition is "normal," it is noteworthy. Similarly worthy of note is the growth of panel discussions with participation by members from the floor, providing the opportunity for our cherished free speech. The deep interest of mem-

bers in their respective tasks, whether they are concerned with providing potable water supplies or the equipment to make that possible, is evidenced by increased meeting attendance and ever more earnest lobby discussions.

An imaginative person flying over this country cannot help being impressed by its varying topography and climate, the drainage and watershed systems, and man's activities in town and countryside. The complexities of man's developments can best be seen at an elevation of 20,000 ft or more above the earth. Transportation, storage, and communication are the basic human contributions to the use of the organic and mineral world. And basic to all, man must have water for himself, his industry, and his agriculture.

The importance of the position of our members in society must never be forgotten in the apparent simplicity with which we serve our people. The well fed customer, remote from primal struggle, realizes less and less the difficulties created by his activities. Since the technical, financial, and legal problems have been resolved in the past, we can expect to apply our talents, as our predecessors have so well done, in the future. One major challenge in the future, if we are to proceed, must be in the field of customer satisfaction and communication. The customer must be made aware of his responsibility in the solution of water supply problems. This is a responsibility of management, and it requires conscious effort of all men connected with our industry.

Public Information

There are many excellent examples of good water utility management, both municipal and private, but there are too many utilities which are seriously in need of aid in finances, legal matters, and staff in order to serve their customers all the water they need when and where they need it.

The Association through its public information committee has been stimulated in this direction. Through the efforts of the committee and the AWWA staff, *Willing Water, Silent Service Is Not Enough,* and numerous other publications have stressed public relations programs of many utilities throughout the Association. These excellent articles and devices have had wide distribution throughout the country, and the possibilities they have suggested have been put into effect by many managers. Such communication of ideas, although not measurable, must have been of advantage in developing a better customer climate for a good many of our utilities.

Newspapers have given information and publicity to water utilities, but many of our cities and privately owned utilities still receive little or no recognition from this source. Newspaper coverage of section conventions is usually poor and only rarely do we see adequate reporting of these excellent meetings in the press. We need to cultivate more cordial relationships with the local press. Editors and reporters may seem to prefer sensationalism to dull fact, but the facts of water supply, being facts vital to community life, need not be dull!

In these last few months of national stress, we have seen the importance of science and engineering admitted by the politician, the cartoonist, and the editor. We of the scientific and engineering world have too long accepted the title of "Sons of Martha" as putting us in our normal place in society. We are not good news copy. A riot, a gangster, a society divorce, or a poli-

tician can command the headlines. Raillery or cynicism on our part with respect to the public or press is no aid to our dilemma. Mass propaganda, although sometimes of immediate value, is of little worth in the long run. The public is apparently easily influenced and has little memory, but it is refreshing, if surprising, to see common sense rise to the uppermost when prognosticators are fooled and pollsters proved wrong.

Clearly our problems of putting the water utilities in their rightful place in the sun, obtaining reasonable returns from our investments, and attracting good energetic men to the profession are the responsibility of this Association, its individual members, and the management and personnel of the utility departments. Cynics may smile and with superior mien cast doubt on all efforts to achieve such an ambition. Yet we have already come a long way, and other utilities have proved that it can be done. The problem does not depend on the geographical area, the peculiarities of a political division, or the size or kind of an enterprise—it rests with the ability of management. If a problem is presented in an engineering manner, it will at least be analyzed and probably solved in engineering fashion.

Because this is the engineering of human affairs, it need not present an insolvable problem. Human frailties and strengths are the basic factors with which our managers and personnel must deal. Impatience with and ignorance of such factors forebodes our defeat in communicating with the public, in achieving public appreciation and understanding, and in gaining public acceptance and positive action when needed.

Consumer Satisfaction

Too long have we slighted public opinion and complained of consumer apathy. We have no rivals in business, no new commodities with which to compete, and no price warfare with the filling station on the other corner. Certainly we represent monopolies and can adopt a "public be damned" attitude. At a recent meeting we heard the consumers classified as "taxpayers" no less, by two eminent engineers, members of this Association. Minutiae, perhaps, but if we call our bosses taxpayers and identify ourselves with taxes, then we cannot resent it if our "taxpayers" call us "bureaucrats" in retaliation. Changing the form of our organization from municipal to commission, or from public to private, or from private to public will in no way change the situation if the same attitudes are allowed to prevail. The consumer is pushed around today, hemmed in traffic lanes, ordered by automatic signals to turn, stop or go, make out forms for this and that, and to give up hard earned money, and to explain on tax forms why he exists. Actually the water consumer is a remarkable Joe. He is not expressive. He is complacent because he is tired rather than disinterested. His natural reaction is to resent intrusion and to want to be left in peace. He hates to see his streets torn up, particularly if he paid for his sidewalk and paving last year, but who wouldn't? He hates a big water bill! Don't we hate a large car repair bill? He hates mud, dirt, noisy bulldozers, dirty strangers, officious managers and clerks. Don't we all? Let's reverse our thinking and sit in his house for a change. Epictetus 2,000 years ago probably was the first man to record these impressions, when

he pointed out that the mirror reflected one's image. Perhaps our average customer is the composite reflection of our utility.

As we must inform our customers by actions developed for his welfare so must we educate our commissions, board, or councils on the importance of the water supply for which they are ultimately responsible. This is no small task and cannot be undertaken lightly or in a disparaging manner. Underestimation of situations and costs is a very human trait. We tend at times to soften the blow just to get the project started. Long and detailed technical reports are rarely read and consequently rarely understood. But complex plans and situations can be clarified by proper methods of presentation. In this we have much to learn. We see many evidences of this in our technical meetings, when costs are described down to the penny and when complex engineering drawings, completely illegible at 5 ft, are used to delineate a general plan.

Why don't we mentally sit in the councilman's chair for a change? People are busy and ignorant of details, but they can grasp situations if the highly technical details or pet ideas are stripped from the main plan. Bold, schematic, and legible drawings or charts reduce the time of comprehension and improve appreciation and understanding. As technical people we tend to raise barriers of misunderstanding between ourselves and others. We fume and fret at attorneys and others about the pedantic nonsense of legal problems. Listen to lawyers discussing the mental rigidity of engineers and you will be shocked.

While we must learn what motivates man (a study conspicuous by its absence in our physical science schools today) we must also learn to inquire into the reasons for our actions, the need for our promulgations, rules, ordinances, and regulations. Most of our rules are unquestionably necessary, but are they only a one-way street, for our benefit or are they intended to be mutually beneficial?

An interesting observation, which should be made by all managers, engineer operators, clerks, and attorneys is that the consumer actually pays our salary. In the modern confusion of business and government this insignificant fact is hidden in the shuffle of paperwork and channels of operation and authority, and we can skillfully ignore this simple fact. At the risk of bad taste, we can call ourselves modern Rebeccas.

This may seem overdrawn. We are convinced that a great part of our position on the utility pedestal is of our own making. We have acted humanly too, probably all too humanly. Since our utility is composed of human beings with all their strengths and inadequacies, we must recognize that, although the successful operation of our undertakings depends on good organization and plans, such success as we may have depends, too, upon the honest individual and concerted effort of all our workers—particularly those who deal with the public and the customer.

The desire and willingness to serve must be stressed to our workers rather than the imposition of set techniques on our individual operations. Although policy statements sound grand, they can become mere emanations from pompous officials and are often treated as such.

Unfailing good manners, prompt service, truthful answers even to dumb questions, good workmanship, and the honest desire to aid the customer will

go a long way toward raising our standards of operation and aid in public realization of the value of our utility. If all this fails, we need an objective look at why we failed. We must not expect miracles but rather the necessity of a long concerted effort to serve, to deliver the goods, to win recognition by positive action, to achieve our desired goals.

Legislative Guidance

It is also time and in many places long past the time when we should unite our efforts at state and federal levels in guiding legislative efforts concerning our operations and welfare. The excellent work of some of our members and of the Association itself in the struggle to obtain reimbursement for the cost of relocating utilities due to federal highway changes is a case in point. The combined efforts of individual members and the Association deserve the thanks of all of us. Progress in this legislation at the state level has not been so successful. A battle for recognition of utilities' rights in this matter must still be fought in future state legislatures. One can also expect to have to defend the present federal legislation.

Similarly our members and managers must be alert to legislation affecting utility operations financing and jurisdiction over operations. Managers, engineers, and others must be ever alert to proposed legislation affecting the water utility industry. Entirely too much law has been enacted without the aid of our representatives.

Creation of new forces of governmental groups which absorb present utilities may or may not be deleterious to the efficient management of the water utilities. There is a sincere belief that many of our economic utility ills can be cured by legislation. Such legislation, often written hurriedly and by amateurs in utility operations, can be ill conceived and create additional difficulties never suspected by the promoters. Utility management should have a voice in such legislative activities. Legislative committees in each section should be alert, fostering well conceived and considered bills and aiding in strengthening or opposing weak legislation. As good citizens we should carry part of the burden of law writing affecting our interests. If we leave this to the mechanics of law writing we must accept the blame for our indifference to our welfare. Most organizations with less at stake than we have are far more alert in protecting their own interests than we are in protecting ours.

As an example, we can point to the fact that much statutory law has been and is being written in the Middle West, East, and South of the United States. This statutory law relates to the use and conservation of water. In some instances state planning boards have been created, ranging in power from ineffective advisory boards to powerful control agencies responsible for all plans for water use. The trend of these agency developments will be to include land planning and overall economic control of land and water use. Creation of adequate and sufficient staff for administering such laws will be difficult. One can expect considerable trial and error in operation procedures at first in such developments. The aid of this Association and its members is needed now and will be more necessary in the future. In multipurpose planning and developing of water projects much remains to be done to resolve the technical and

administrative conflicts inherent in such schemes.

Research and Management

Only by very careful and well conceived economic and technical studies framed in an atmosphere of tolerance and understanding, based on sound statutory law and administered by conscientious but tolerant agencies, can we expect to achieve some watershed management in its broadest sense. This is, as a practical matter, difficult if not impossible to achieve. One thing, however, is sure: ignoring our needs or failure on our part to participate in such programs will not gain for us our required allotments and will certainly provoke our customers at a future date. It is wisdom for us to know our wants, recognize other's needs, be positive in our demands, and if necessary, defend our position. Surety and respect will not be obtained by provincial thinking.

One of the major problems facing our engineering and planning staffs is the lack of basic meteorological, hydrological, and topographical data and the need for more information on water quality. Numerous agencies both state and federal are, within the limits of their budgets, developing and publishing such data. In some instances there may be an overabundance of data available while in many others there is a lack. Unquestionably, there is need for closer coordination of these activities to eliminate waste of time, effort, and money, and the members of our Association can join in the support of better data gathering and of basic research in the use of data.

Although technical developments will be of more concern to many of our members, more stress in the future should be placed on management problems. From our technical staff come many of our managers. If we are to attract young men of all categories into our fold and Association, we must use all our efforts in developing our utilities in a positive fashion, looking forward to producing better water supplies for our customers where and when needed. These are the steps which must be climbed if we are to put ourselves in our rightful place in the utility sun—and in the public eye.

Automation Developments in Philadelphia

Victor A. Appleyard

A paper presented on May 13, 1957, at the Annual Conference, Atlantic City, N.J., by Victor A. Appleyard, Chief of Water Operations, Water Dept., Philadelphia, Pa.

THE word automation has become an extremely popular one in America today. Webster's definition of *automatic* with reference to machinery or mechanical devices is "self-acting or self-regulating." Of recent origin, the term automation is being used to cover much more than single devices. A recent definition of automation which is very good is: "The system and method of making processes automatic by the employment of self-controlling, self-acting machines for performing the necessary operations." By this definition, it is obvious that automation has existed in water works for over 30 years. For instance, if a whole water works system consisted of only a pump and tank—as on a typical farm system—and the pump was controlled by a float or pressure device, then it could be said that complete automation was accomplished. Public water systems, however, are not usually this simple and elementary in their design and operation. There are filter plants today that are practically fully automatic as are many pump stations. But nowhere does complete automation exist, where the whole process, from source to sink is completely automatic.

Since World War II, new equipment, new approaches, and new techniques have been developed to handle very complex processes to the point where complete automobile engine blocks are machined automatically; guided missiles are launched, tracked, and guided by automatic systems; archaic office procedures are supplanted by giant computers; and where a completely automatic oil refinery is being constructed.

At Philadelphia, many of the various systems available have been under consideration for the past 2 years. A specification is now almost completed for purchase and installation of some of the specialized equipment which will readily lend itself to ultimately complete automation when it becomes desirable in the future. The basic job to be accomplished at this time is establishment of a load control center which will have an intelligent function, as well as supervisory control of various pumping and valve functions.

Philadelphia Water System

The need for such a center can readily be seen if one considers the complexities of the system at Philadelphia. The city covers 130 sq miles and has a population of approximately 2,170,000, with a large number of industries within the city limits. The ground elevations range from river level—zero—to 440 ft. The water system, over the last 157 years, has developed to meet population growth, using the two river sources to best advantage, from the standpoints of safe and dependable supply and the variety of elevations served.

The Delaware River has one large intake at Torresdale, a 300-mgd raw-water pump station, a 200-mgd slow sand filter plant, and a filtered-water pump station that has 200-mgd capacity, as well as high-service pumps of 15-mgd capacity. From this same filter plant, the Lardner's Point pump station receives clear water by gravity through a 10.5-ft tunnel about 3 miles long. This station has a 210-mgd capacity. Oak Lane and Fox Chase are two pump stations that boost this same water; the first has 40-mgd capacity, and the latter 15-mgd. This river system now supplies about 50 per cent of all the water the city uses. During an average day last year the total amounted to 369 mil gal.

The Schuylkill River division has three intakes. One is at Belmont, and has a raw-water pumping capacity of 195 mgd. The water is pumped into a sedimentation basin where it is divided —half passing through the 60-mgd capacity slow sand filters, and half through the 36-mgd rapid sand plant. Eighty per cent of the finished water feeds the Belmont service area by gravity—16 per cent being pumped by a high-service station of 40-mgd capacity. The second intake is Queen Lane, a pump station of 200-mgd capacity, which delivers the water to a 178-mil gal sedimentation basin 220 ft above the pump level, a pretreatment plant, and a filter plant of 120-mgd normal capacity. Most of this water flows by gravity to the downtown section of the city, and the remainder feeds into the triservice area by high-service pumps located at the filter plant. The third intake is at Shawmont, a station of 50-mgd capacity, which pumps to a large settling basin with a capacity of 147 mil gal. A booster station pumps from this basin to the Upper Roxborough filter plant which, in turn, supplies an average of 13 mgd to the high-service pump station and 7 mgd to the triservice area.

The Chestnut Hill plant is a very small booster, taking suction from the Roxborough high-service system. There is also a Lower Roxborough filter plant which supplies by gravity 3.5 mgd to the Manayunk area.

The East Park booster plant—75-mgd capacity—is designed so that it can boost either into Center City, or into the Belmont system in cases of emergency. In addition to the potable water system, there are two high-pressure fire stations which serve the principal business district. This is a separate system and uses untreated river water for half its source and the domestic system for the remainder. Water is drawn from a basin to avoid cross connection.

All plants and stations are tied together with about 2,900 miles of pipelines—ranging from 93 in. to 4 in. in diameter. In order to operate with maximum efficiency and reliability, the distribution system is divided into twelve service areas, a few of which have some clear water storage.

At connections where the hydraulic gradient of two service areas are equal, valves between the areas are left open and the water blends. At connections where a considerable difference exists, the connecting valves are normally kept shut.

In the operation of the plant as a whole, it must be decided daily how best to utilize the maximum amount of the least expensive water in all the areas while maintaining service pressure standards. All facilities must be put to maximum use to handle peak hourly rates at minimum cost and maximum dependability.

Automation Equipment

The equipment for the intelligence system can be subdivided into three functional groups: the transducer, which includes the primary detector; the telemetry; and the data reduction and logging function. The transducer is the device which accepts primary information such as pipeline pressure, differential pressure across a venturi tube, and similar data. It may be equipped with a pulse generator, tone generator, or even an analog to digital converter. The data from the transducers is presented to the telemetering transmitter for transmission to the load control center via wire lines or microwave channels. The transmitter output is a signal or signals basically telegraphic in nature and takes the form of pulse duration, a variable-frequency voltage, a direct current, a variable tone, or a signal in the radio frequency range. There are many types of telemetering systems but, in general, all of the systems use either the pulse rate or pulse duration method, of which the frequency type falls under the impulse rate system.

The transmission of the intelligence to the load control center from a single source with but one variable is a fairly simple operation. In the vastness of the Philadelphia system, however, as many as twenty variables will be transmitted from a single location. By means of high-quality stepping or programing switches, the variables can be transmitted individually at a high repetition rate, or simultaneously (within frequency limitations of the equipment employed) and programed at the load control center. Actually, there is equipment available that can receive signals in 10 μsec (10 millionths of a second) and have to be stored on a memory drum or tape. This is expensive equipment and obviously not needed in water works, but it is mentioned to demonstrate what is available today in the field of telemetry.

Where there is more than one differential pressure recording the total flow out of a pump station, a totalizing mechanism will be used so that a signal indicating the total flow from the station will be sent to the control center. In other words, there will be some computing equipment, but, as in this instance, of a minor nature.

At the moment, it is expected that approximately 120 readings from 33 different locations will be brought into the control center. This presents a considerable problem in telemetry. Philadelphia has its own automatic telephone system and, where dry pairs of conductors are available to these various locations, one pair will be used to each location. This system, however, has not reached a number of remote parts of the city and, therefore, microwave techniques are contemplated in order to bring remote readings into a subcenter, from which they will be programed over telephone wire to the control center.

This combination of equipment is being studied in comparison with complete microwave transmission of field data, and the final decision has not yet been made. Microwave transmission is basically a radio technique employing frequency modulation which operates in a narrow-beam, line-of-sight path. Due to the low level of microwave frequencies in static discharges, natural and man-made static is practically nonexistent—insuring uninterrupted communications.

Last stage in the system consists of equipment which receives and processes the signals through data reduction, so

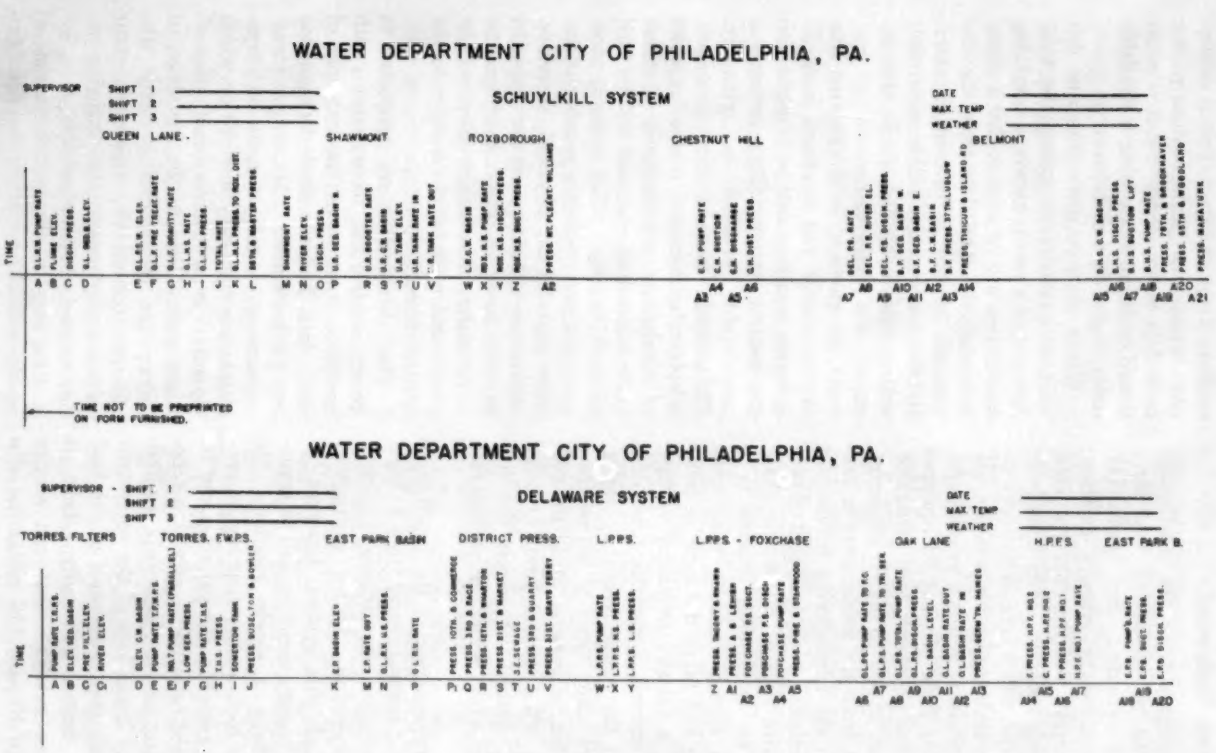


Fig. 1. Log Sheets

After signals have been received and processed, information is automatically typed on the log sheets by electric typewriters.

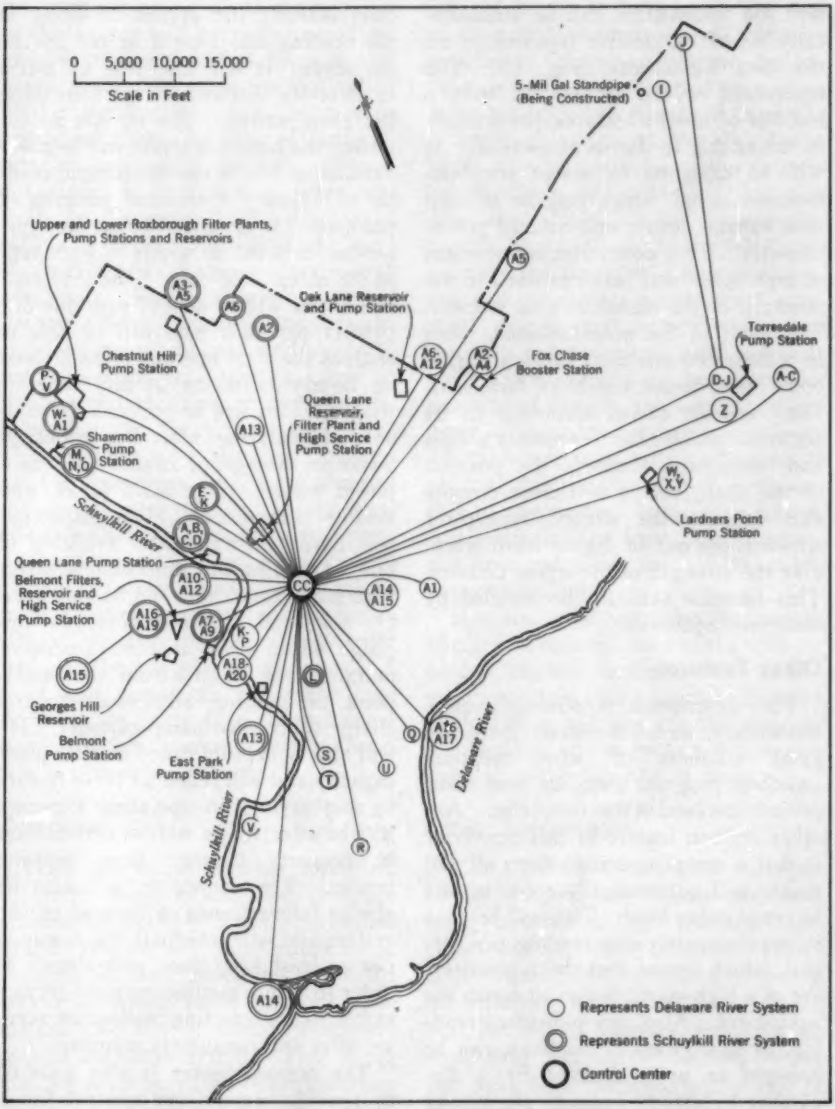

0 5,000 10,000 15,000
Scale in Feet
5-Mil Gal Standpipe (Being Constructed)
Upper and Lower Roxborough Filter Plants, Pump Stations and Reservoirs
Oak Lane Reservoir and Pump Station
Chestnut Hill Pump Station
Fox Chase Booster Station
Torresdale Pump Station
Queen Lane Reservoir, Filter Plant and High Service Pump Station
Shawmont Pump Station
Schuylkill River
Lardners Point Pump Station
Queen Lane Pump Station
Belmont Filters, Reservoir and High Service Pump Station
Georges Hill Reservoir
Belmont Pump Station
East Park Pump Station
Schuylkill River
Delaware River
CC
Represents Delaware River System
Represents Schuylkill River System
Control Center

Fig. 2. Plants, Stations, and Mains of the Philadelphia Water Distribution System

Circled code letters—signal transmitting points—correspond to those on log sheets shown opposite (Fig. 1). Lines radiate to various points from the control center (CC).

that the information can be automatically typed by electric typewriters on the data log sheets (Fig. 1). The equipment at the center will have a number of unique features, particularly in the analog in digital conversion. It will be designed to accept the telemetered signal, which may be of variable voltage, into a null-balance potentiometer. This potentiometer operates at high speed and balances itself to the strength of the signal in split seconds. The shaft of the potentiometer, when in a balanced position, turns a digital conversion device which, in turn, activates specific relays according to its position. Each relay represents a digit and, therefore, whatever the position of the shaft, relays will close circuits that activate the electric typewriter which types out in digital form whatever the strength of the signal dictates. This function can also be handled by electronic equipment.

Other Features

This description is obviously quite elementary, and, of course, there are great amounts of wire, stepping switches, program switches, and other devices involved in this converter. Another built-in feature of this converter is that a complete record from all 120 points will automatically come in and be typed every hour. This will be done in approximately one reading per second, which means that the typewriters are of a high-speed design to match the equipment. Also, any individual reading, or any group of readings, can be brought in upon demand by a dispatcher by merely pressing the proper button. Besides this, the field points will be scanned at the rate of about one per second, and will be matched against preset limits. If the variable exceeds these high-low limits, it will automatically activate the system to bring in the reading and type it in red on the log sheet. It will also ring an alarm to alert the dispatcher that something has gone wrong. The equipment for setting the high-low limits will be made variable so that it can be changed readily to follow the seasonal patterns of pumpage. It is expected that the typewritten data will be within ± 1 per cent of the actual field data. The load control center will be staffed with one dispatcher per shift who will be able to analyze the total operations on at least an hourly basis—or at any time he wishes. This will be particularly valuable in analyzing what has happened when an emergency occurs such as a power outage, large main break, and similar occurrences. The dispatcher will have two-way radio available to him so that he can immediately direct emergency crews into the trouble area. On abnormal load conditions, he can judge which plant is best capable of pumping the water—from the standpoint of creating additional demand charge or reserve pump capacity. He will also be kept informed of filter plant capacity and will relate all these factors so that savings in operating expenses will be effected, as well as a reduction in property damage from pipeline breaks. The dispatcher will also be able to follow trends of demand on the system and will anticipate the demands (or at least keep pace with them) in order to insure continuing good service rather than correcting inadequate service after the consumers complain.

The control center is also planned to provide supervisory control for a number of remote stations. This control will be designed so that the same pair of telephone lines and the microwave channel used for data reduction will also be used for transmission of

the control signal. Final development of this center will not only permit remote operation of pumps, but will permit operation of large control valves in the distribution system, as well as providing alarms in case of malfunction of unattended chlorine stations. An alarm is contemplated that will alert the dispatcher if an unattended station is broken into or if the temperature inside the station rises beyond safe limits. This equipment will be of the type that will interrupt the data circuit long enough to command a specific function—such as putting a pump on the line and receiving confirmation by light that the function is completed. The load control dispatcher can then get valve readings on the log sheet of the service area affected to see what effect this action has had on the system.

The complete system (Fig. 2) will provide a "nerve center" for the whole plant. Complete control will be virtually at the fingertips of a dispatcher who will be on duty at all times. A chief load dispatcher will make final decisions on other than normal functions, particularly when a special operation is planned in advance.

Computer

With the installation as described, the only thing lacking for complete automation would be a computer which would receive all this information, evaluate the load conditions of all the service areas, and make decisions automatically so that it would completely operate the whole system. This would involve what is called "feedback circuitry" and would use the same means of telemetering as that used for data collection and supervisory control. Obviously, a computer for this purpose would be a complex electronic device because it would have to detect first an abnormal circumstance and then, by a series of formulas, compute the answer or action needed, and then compute feed-back and command functions in order to satisfy all the conditions, which involve not only service criteria but economy of operation. At this time, this would not be economically feasible because it would probably only supplant the function of four dispatchers, and the cost of a specialized computer, such as would be required, would run into a tremendous capital investment. It is to be noted, however, that this type of system (including the computer for complete automation) is being designed and installed in a petroleum plant at this time, so that it is reasonable to assume that in the near future, computers will be built as a commercial item and their cost will be within reasonable limits.

It is also to be noted that the savings effected in reduced personnel (with attended stations replaced with supervisory control) plus a greater efficiency of operation will pay for the expense of installing and operating this equipment in a short period of time.

Other Applications

There are a few other areas susceptible of automation. Some are now being adapted to the technique and others are still being studied. Philadelphia now has computers performing the following functions:

1. Recording location and changes of all meter locations (520,000 meters will have been installed by the end of this year.)
2. Computing meter shop wage incentive payroll
3. Setting up meter shop and, ultimately, all department inventories

It is also planned to put valve, hydrant, and main break histories on punch cards soon.

Automatic Meter Reading

In the area of meters and meter readings, some real thought has been given to a problem confronting most utilities at this time. It is particularly true of those utilities, such as gas and water, which have meters installed inside the home. On the resetting of meters, as well as meter reading, a "no response" as high as 30 per cent has been experienced. This means that during the normal work week there is nobody at home and hence no entry for water works employees. This requires backtracking a number of times and, ultimately, Saturday work is required in order to obtain the meter readings in all homes. Discussions have been held with the telephone company which have indicated that it was possible to read water meters through an inexpensive telemeter attached to the meter and connected to the telephone circuit. Practically every home in this city has a telephone and, therefore, it would not be necessary to obtain entrance in order to obtain a reading. The telephone company could probably read out an exchange in a half day and turn them over on a punch tab to the billing department which, in turn, could feed the tab through an automatic billing machine. This billing machine would be equipped to compare the reading to a predetermined standard reading so that if an abnormal reading is indicated, the account would not be billed, but ejected from the machine for further checking. Possibly 95 per cent of all accounts could be read and billed on a virtually automatic basis, and the degree of accuracy would be at least equal, if not greater, than methods now used. Again, the equipment at this time may be expensive and not economically feasible. The rate of new development of instrumentation in the electronic field, however, is so great that it may be reasonable to assume that this can be done in 5–10 years.

Conclusion

It is mandatory that the water works utilities be ever on the alert to keep abreast of new advances in science and methods. The fact that "Too Cheap Water" is served is enough to require the industry to keep up with new, better, and more economical ways to serve its customers.

Use of the McIlroy Analyzer on Water Distribution Systems

Charles L. Barker

A paper presented on Apr. 5, 1957, at the Montana Section Meeting, Great Falls, Mont., by Charles L. Barker, Prof., Dept. of Civ. Eng., State College of Washington, Pullman, Wash.

THE McIlroy Analyzer is an electrical device which employs a panel board on which can be represented all the essential parts of a water distribution system. It was developed by the late Malcolm McIlroy of Cornell University and was first presented to the water works industry in April 1950 (*1*).

On this equipment, special resistors are connected to represent the distribution system. When electricity is fed to the system, pressures can be determined by reading voltages, and flows can be determined by reading currents. In this way, the operation of the system under many sets of varying conditions can be rapidly determined.

Since the time of its introduction several installations have been made in laboratories, and several hundred cities have made use of this type of equipment in studying the operation and planning the expansion of their distribution systems.

The State College of Washington purchased the first commercial model of the analyzer ever built, and it has been used by consulting and city engineers from Fairbanks, Alaska, to Caracas, Venezuela. Last summer, Baltimore and Philadelphia placed in operation large analyzers for their water departments.

Development

As early as 1924, engineers attempted to use electrical networks to solve pipeline network flow problems. The difficulty was that the voltage drop in the electrical circuit follows Ohm's law, $E = RI$, where I is the flow of current, whereas the hydraulic circuit has a relationship in which the head loss varies as the rate of flow to the second or 1.85 power. McIlroy developed an electrical resistor * that had a voltage drop to the 1.85 power of the current flowing. With this type of resistor in an electrical circuit he was able to get perfect similarity between the electrical and hydraulic systems. The commonly used Hazen-Williams formula states that the head loss as $k_p Q^{1.85}$. The governing equation with the resistor is $E = kI^{1.85}$, where k is the coefficient of the resistor.

Ratios of current to rate of flow must be selected; for example, 1 amp is equivalent to 1,000 gpm, and 1 v equals 4 ft of head. Using these scales and knowing the kind and condition of the pipe used, one can select the proper k value in the $E = kI^{1.85}$ equation. The resistors come in about 250 sizes so that one can represent almost any size of pipe, any length, and any roughness. By placing these fluistors in a network which duplicates the hydraulic system, one can make a study of the system very rapidly.

* Now manufactured under the name Fluistor by Standard Electric Time Co., Springfield, Mass.

Parts

The analyzer panel board consists of several parts (Fig. 1). First is a network panel on which the resistors are placed in their proper relationships (Fig. 2). Second is the source panel which provides sources of electricity at different voltages just as water is added to the distribution system at different pressures by pumps and reservoirs. Some analyzers have 36 sources available. The third part is the load panel on which thousands of points of water withdrawal can be represented. The fourth part is the map panel representing the distribution system to be analyzed. The control panel on which are mounted various controllers and meters is the last part. On the network panel one can plug in an ammeter and measure the flow at any point, not only in quantity but in direction. Thus, by making the proper electrical connections the operator can determine the pressure at any point in the system.

A series of maps (Fig. 3–7) of a distribution system serve to demonstrate the use of the analyzer. Figure 3 gives pipe sizes and lengths and topographic data. Figure 4 shows the system in operation on an average day. The flows indicated are read directly from the analyzer. In all the maps shown, 1 amp is equivalent to 500 gpm and 1 v is equal to 2 ft of head. Figure 5 shows the system of Fig. 2 with loads increased 50 per cent and Fig. 6 shows the system with an addition of

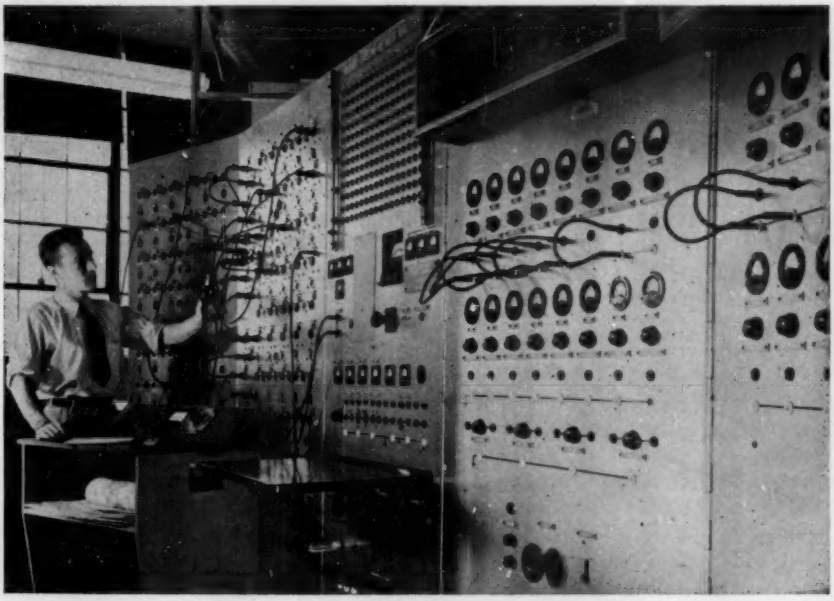


Fig. 1. Front of Analyzer Panel Board

Problem is in process of solution.

a 12-in. pipe. Two flows are shown from the tank, one without the pump, the other—reduced—with the pump. Figure 7 shows the effect of an 8-in. tie with 1,000 gpm being drawn at the high point.

Operation

Information needed to use the analyzer includes the map of the network to be analyzed, pipe sizes and lengths, material or *C* values, load location, sources, topography, and expected maximum flows for the expanded system. The length, roughness, and size of the pipe are all included in the *k* value.

Variations in topography are taken care of by the fact that the analyzer measures head loss along the pipe. For example, if the loss from *A* to *B* is 20 ft and *A* is 10 ft above *B*, the pressure head at *B* is 10 ft less than at *A*. Elevations of reservoirs and such structures are set in the analyzer only as an arbitrary figure because the important item is the head loss.

Electricity is applied to the analyzer as direct current at any junction point. Almost any number of sources can be used simultaneously. Loads are drawn off by a patch cord system through meters which are individually regulated. In the present system, 32 loads can be manipulated.

Expansions are usually handled by adding loads to represent the effect of subdivisions. To save time, the total maximum demand for the future is needed in order to select the scale. For example, if it is assumed that the future demand is 100,000 gpm, a scale of 1 amp equals 10,000 gpm is used because just over 10 amp of current are available. The maximum range of pressure head drop is needed to select the voltage scale, such as 1 v equals 2 ft of head or, perhaps, 1 v equals 10 ft of head for extreme ranges.

Junction numbers are used to designate points on the analyzer at which the flows for corresponding points on the system can be checked. Flow direction is determined by the use of a polarizing plug on the ammeter. The flow direction is determined by the increase or decrease in the meter reading.

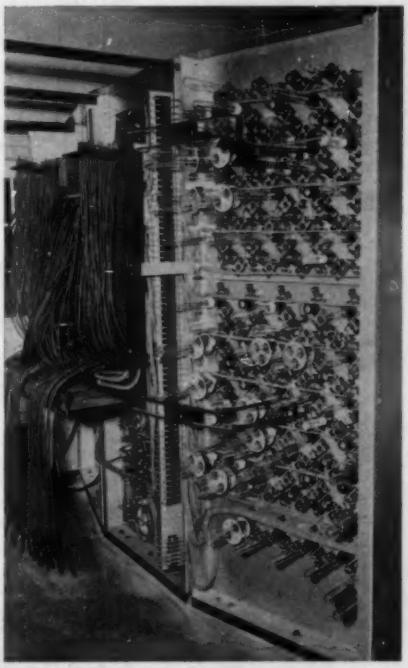
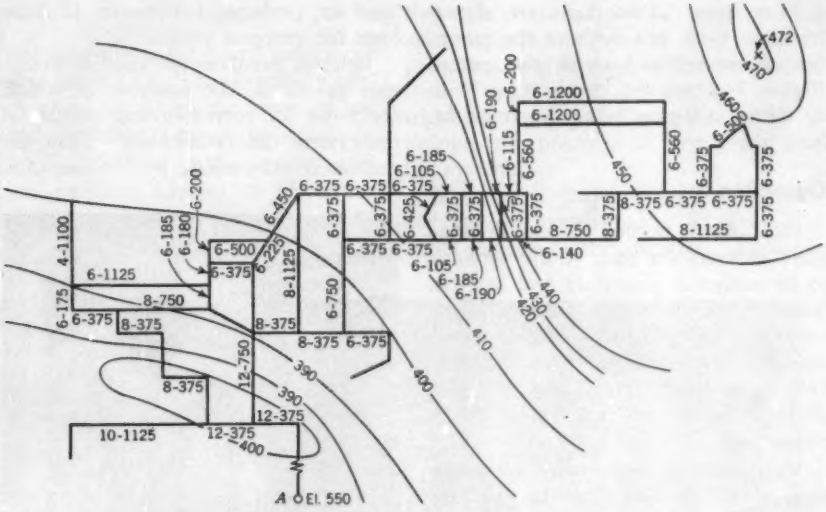


Fig. 2. View of Back of Panel Board

Network and source panels are shown.

To measure the elevation of the hydraulic gradients, the source or sources are first adjusted to give the correct flows. The head loss along each pipe is then determined, as well as the voltage at the source. With the elevation of the hydraulic gradient at the source known, losses from the source to the


6-1200
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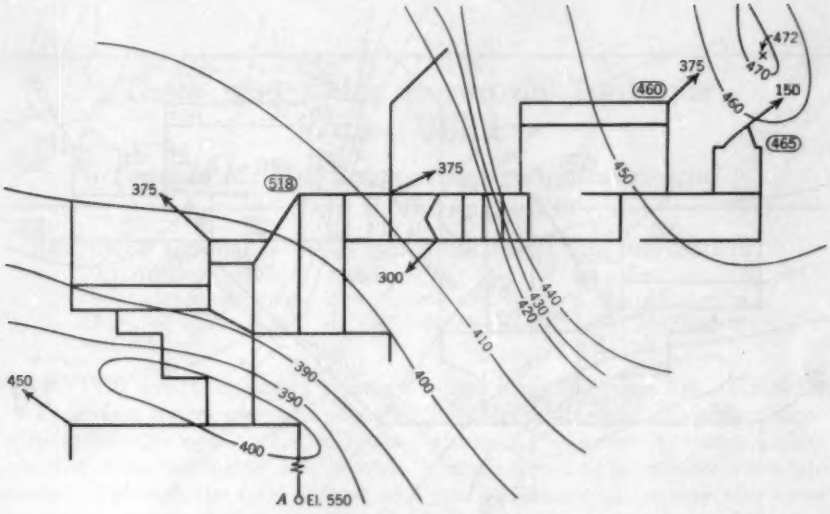

Fig. 5. System With Loads Increased

System is the same as shown in Fig. 2, with a load increase of 50 per cent. Circled figures, hydraulic gradient; others, loads.

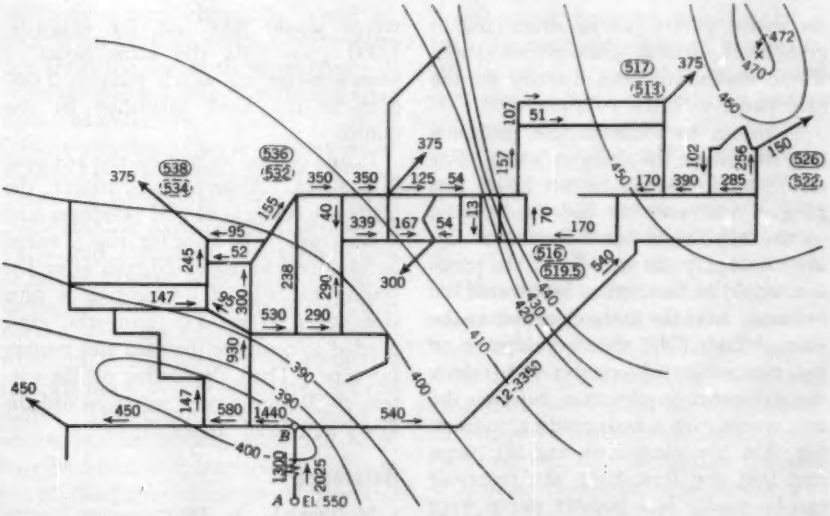

Fig. 6. System With 12-in. Pipe Added

The addition extends from the tank, A, to the high point. Figures circled with broken lines represent hydraulic gradient without pump station, B. Flow figure from tank with pump in operation is underlined. Pump has 750-gpm capacity.

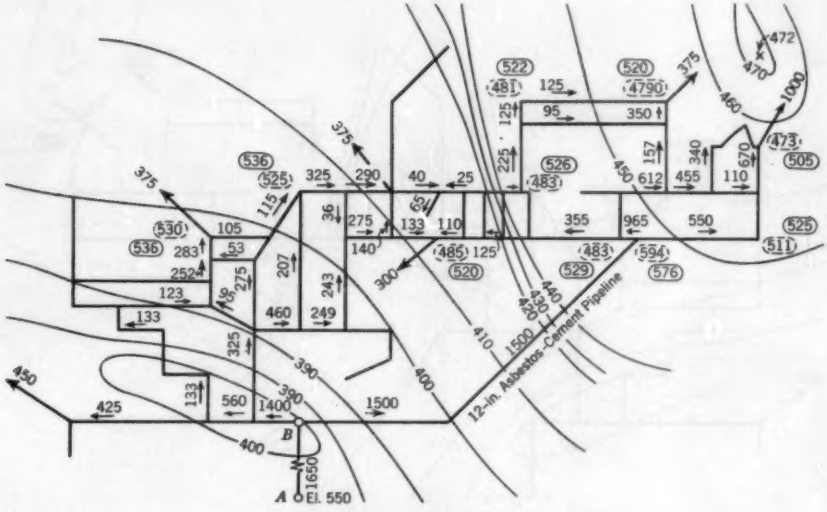

Fig. 7. System With 8-in. Tie Added

Numbers circled with broken line represent hydraulic gradient before 8-in. tie; those with solid lines, after.

successive points can be subtracted to give the hydraulic gradient elevation. These losses are read directly on the map panel with the voltmeter.

Solutions to some sample problems may illuminate the analyzer's use. For example, if, instead of the 12-in. line (Fig. 4), a reservoir had been placed on the hill (right-hand portion of figure) to supply the peak flows, the problem would be handled as follows: If the reservoir is at the same elevation as the storage tank (*A*), then a voltmeter on the control panel connected to show the difference in elevation between the two would give a zero reading, indicating that the elevations are the same and that the flow from the reservoir can be read. If a booster pump were installed in the network it would be integrated into the analyzer as a load which would take out, for example, 1,000 gpm. At the same point, a source is set up which puts in 1,000 gpm at the head furnished by the pump.

Loads can be shifted on the analyzer in 2–3 min. After perhaps 10 min, the loads are rebalanced and pressures and flows read. The data for Fig. 3 could be obtained in about 20 min after the setting for Fig. 2. Changing a pipe size takes from 3–5 min—the time needed to compute the data and replace the pipe. Then, depending on the system, 5–20 min is required to record the flows and head losses.

Reference

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Taste and Odor Research Tools for Water Utilities

Francis M. Middleton, Aaron A. Rosen, and Rice H. Burttschell

A paper presented on May 14, 1957, at the Annual Conference, Atlantic City, N.J., by Francis M. Middleton, In Charge, Organic Contaminants Unit; Aaron A. Rosen, San. Engr.; and Rice H. Burtschell, San. Engr., all of the Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

WATER utility operators treating surface waters are often plagued with tastes and odors. Expectations are that these conditions will become worse. Although the total amount of available water remains relatively constant, populations and industries which contribute taste- and odor-bearing pollutants to water are on the increase. The upsurge in production of the newer synthetic organic chemicals focuses attention on possible water quality damage from the use of these materials or from the waste products resulting from their manufacture. Table 1 shows how production of some of these materials has increased over the past several years. A population increase of about 50,000,000 is expected in the next 25 years and industrial production, now at record heights, is expected to double in the same period. It is known that most tastes and odors in water come from organic materials, but even this information leaves a vast area to explore. The organic contaminants of water, besides causing taste and odor, may interfere with coagulation, damage ion exchangers, and create chlorine and carbon demand. In the stream they may have adverse effects on aquatic forms that support higher aquatic life, cause off-flavors in fish flesh, or have direct toxic effects on fish. Excessive production of algae or other aquatic plants may be caused by man-produced materials such as phosphates and nitrogen. Such organisms may also cause taste and odor and filtration difficulties at the water plant.

Much progress is being made in the treatment of both domestic and industrial wastes. For the reasons mentioned above, however, it is difficult to keep the net pollution from increasing. Water reuse is expected to increase, and possible buildup of organic matter will need careful assessment under such conditions. Tastes and odors can result from remarkably low concentrations of some materials, thus making treatment and removal problems more formidable. Some of the chemicals isolated from water, along with the concentrations which can be detected by odor, are shown in Table 2.

Methods for control of taste and odor at the water plant are well-known. Although the methods are effective for the most part, they sometimes fail and, of course, represent considerable expense to the utility. It is difficult to control the unknown, and most taste- and odor-producing substances have remained in that category.

TABLE 1

Production of Synthetic Organic Chemicals

Item	Production—*1,000,000 lb*					
	1925	1937	1950	1953	1956	1975
Plastics	46	315	2,151	2,777	3,977	9,000
Fibers	58	329	1,496	1,499	1,600	
Medicinal chemicals	3	17	49	67	89	
Surface-active agents	0	9	676	922	1,072	4,000
Solvents	650	1,300	3,200	7,890		
Insecticides and other pesticides	27	102	286	297	570	

Research Projects

Because of the increasing importance of organic chemicals in water and the lack of knowledge of the kinds and concentrations present, one phase of the water quality research at the Robert A. Taft Sanitary Engineering Center for the past several years has been aimed at the isolation, identification, and evaluation of these organic materials. Specialized techniques have had to be developed for these studies since ordinary methods were inadequate. The techniques and early findings on this project have been reported in the JOURNAL (*1*) and elsewhere (*2, 3*). A principal sampling method involves the use of a small filter containing activated carbon through which several thousand gallons of water are passed. The carbon adsorbs the organics from the water. After the carbon is dried, it is put into an extraction apparatus and the adsorbed materials are extracted with organic solvents—first chloroform, then alcohol. Removal of the solvent by distillation leaves a residue. This organic complex is subjected to further study, including odor tests.

TABLE 2

Concentration of Some Chemicals Causing Taste and Odor

Substance	Concentration detectable* *ppb*
Formaldehyde	50,000
Picolines	500–1,000
Phenolics	250–4,000
Xylenes	300–1,000
Refinery hydrocarbons	25–50
Petrochemical waste	15–100
Phenylether	13
Chlorinated phenolics	1–100

* Concentrations were determined by taking the median of 4–12 observations.

This article describes recent research findings and advances in methodology. In addition, it outlines how the methods for studying organic matter can be utilized by the water utility profession. It is believed that with widespread use of these approaches, along with those that are certain to develop with many people studying the problem, progress can be made in understanding the complex role of organic chemicals in water. These techniques are being used successfully by several companies and water plants.

Measurement of Chemicals

One of the first questions to be asked is: In what concentrations are these organic chemicals occurring in waters? The concentrations of chloroform- and

alcohol-extractable organic matter from untreated water supplies from several sources are shown in Table 3. It is clear that those streams known to carry low pollution loads, such as the Coloradio and Columbia Rivers, show few recoverable materials. More highly polluted streams may carry ten times as much organic contamination. The material recovered by the two solvents does not include all of the organics present. More rigorous extraction procedures may recover additional amounts of organic matter, but these materials are not believed significant from the taste and odor standpoint.

TABLE 3

Recovery of Organics From Raw Water

River	Location	No. of Samples	Avg Recovery of Extracts—*ppb*		
			Chloroform	Alcohol	Total
Colorado River Aqueduct	LaVerne, Calif.	4	39	160	199
Columbia	Bonneville Dam	4	33	87	120
Detroit	Wyandotte, Mich.	5	201	264	465
Mississippi	Minneapolis, Minn.	4	127	350	477
Mississippi	Quincy, Ill.	5	122	335	457
Mississippi	New Orleans, La.	4	122	478	600
Missouri	Kansas City, Kan.	3	88	455	543
Merrimack	Lawrence, Mass.	4	322	421	743

Such information, which any water plant with modest laboratory facilities can obtain, serves as a base line of pollution. Substantial changes in water quality due to industrialization or other causes are apt to be evident. Knowledge that tools are available for measuring pollution may in itself deter a polluter.

One of the reasons why the organic materials are of significance is that many of them pass through normal water treatment almost undiminished in quantity. Table 4 shows results obtained from two raw and finished waters. Occasionally, more materials will be recovered from the finished water than from the raw water. One possible explanation of this would be the formation of compounds which are heavier after reaction with chlorine. For example, 1 g of phenol in raw water would weigh approximately 2 g in the finished water if the material were converted to trichlorophenol through reaction with the chlorine applied at the water plant.

Composition of the materials may be changed by oxidation processes such as chlorination, and a reduction in odor may occur. But the process stops short of oxidation to carbon dioxide and water. Such conditions would be ideal. Actual removal of most organic matter from water is presently limited to adsorption onto activated carbon. Carbon treatment as generally practiced, however, does not remove the bulk of the materials, although it renders the water palatable. Actually, it may not be essential to remove all of the substances. For economic reasons or because of the limitations of feeding facilities, it is often not possible to apply

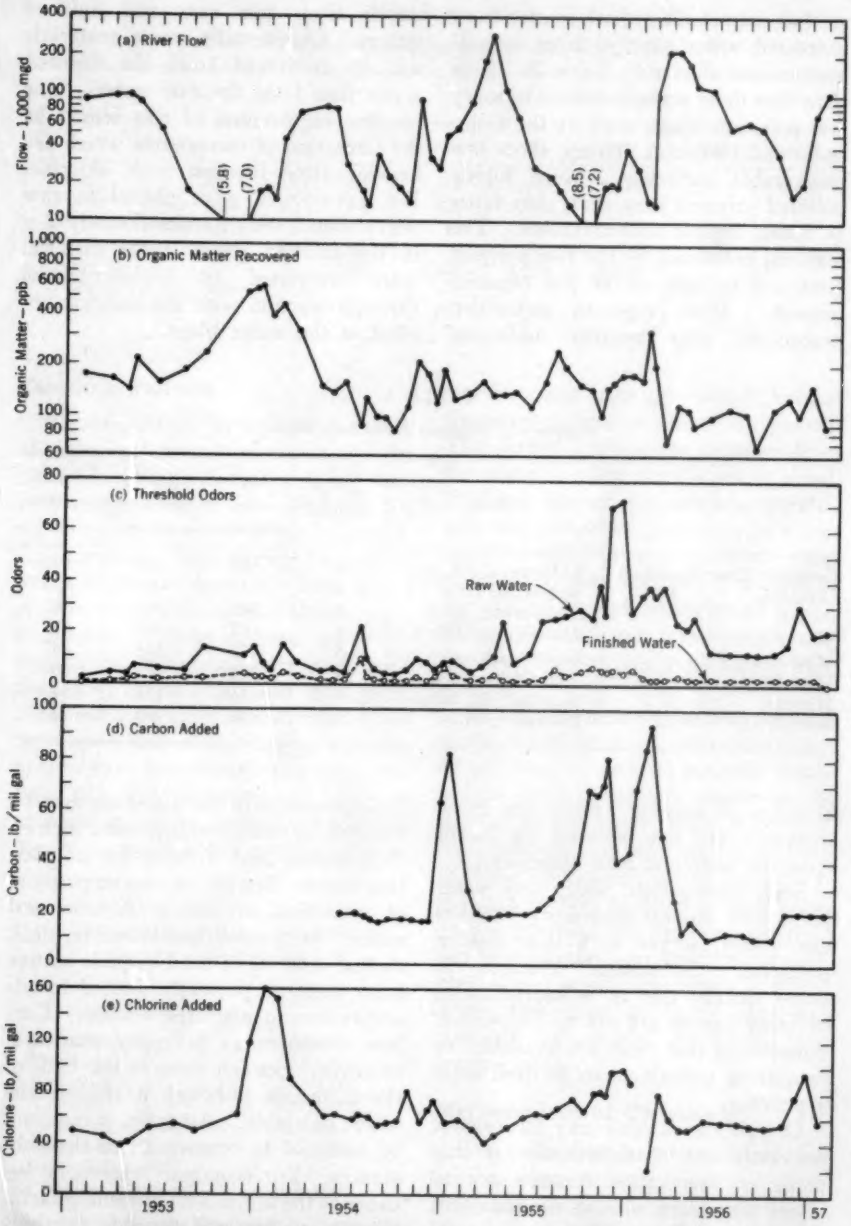

Fig. 1. Data on Raw and Finished Water at Cincinnati, Ohio

(*For explanation, see bottom of facing page.*)

the amount of carbon needed for complete taste and odor control or for total removal of organic matter.

Studies of Cincinnati Water

Cincinnati, Ohio, tap water has been monitored for organic matter by means of carbon filter tests for a 4-year period. The Ohio River, source of Cincinnati's water, receives a variety of industrial wastes and a large quantity of domestic sewage, but there are no large sources of pollution for many miles above the Cincinnati water intake. The organic pollutants recovered have usually had long periods in which to stabilize in the river and may be considered "old pollution" as contrasted to those pollutants that may have a short time of travel from origin to water intake.

Figure 1 is a graphic representation of the quantity of chloroform extractables recovered during 2–4-week sampling periods. With the same timescale, data have been plotted for threshold odors of raw and finished water, river flow, rate of application of carbon, and rate of chlorine added for free residual treatment. It is the purpose of Fig. 1 to indicate whether correlations exist among the various factors that relate to taste and odor. The following correlations and observations are of interest:

1. *Relation of flow* and organic content.* The highest level of organic matter recovered from tap water occurred during a sustained low-flow period in late 1953 and early 1954. With increasing flow in the river, the organics in the tap water decreased. It will be noted that the concentration of organics may sometimes increase when the river is rising. This is particularly true when gentle flushouts occur. Stirring of bottom deposits can account for this to some extent. The low-water period from September to December 1955 was not accompanied by an expected increase in organic content. Carbon treatment is no doubt partially responsible for this. During most of 1956 river flows were high. Carbon feed was minimal. Organic content

TABLE 4

Concentrations of Organic Chemicals in Raw and Finished Water

Sample	Chloroform Extractables—ppb	
	Raw Water	Finished Water
Detroit River		
1	154	75
2	491	436
3	361	358
4	45	65
5	165	104
6	129	124
Missouri River		
1	186	136
2	65	27
3	40	33
4	43	89

* Flow data in some instances are provisional and subject to change. (Source: USGS.)

Explanation of Fig. 1 (see facing page)

Curves are plotted, as labeled, for: (a) average Ohio River flow, (b) organic matter extracted by chloroform, (c) threshold odors, (d) rate of carbon dosage, and (e) rate of chlorine dosage (raw water) for free residual treatment. The break in the curve for Fig. 1e indicates a chlorine failure in early 1956, due to high demand and other difficulties.

was low and reflects the good condition of the river.

2. *Relation of threshold odors of raw and finished water with the organic content of the finished water and the river flow.* Threshold odor data are of course difficult to interpret due to their subjective nature and the wide variations that may occur. Hence, unless a large amount of data collected by controlled panels are available, the results must be evaluated for what trends they may show. Peak odors in the raw water were observed in November and December of 1955, a period of river flushout. A second surge occurred in February and March of 1956. In the period from April to September 1955 a consistent rise in odor was noted, while the river flow was decreasing. Consistently high river flows in the last half of 1956 were accompanied by consistently low thresholds in the raw water and, as noted before, low organic content.

Threshold odors of the finished water show only slight correlation with the organic matter recovered. Moreover, threshold results may not always reflect consumer acceptance of the water. During the peak of organic contamination (late 1953–early 1954), tastes and odors were more objectionable than at other times when thresholds were higher. Most of the odor in the organic extracts from Cincinnati water is found in 5–10 per cent of the material (as determined by conducting steam distillation tests of the residues), and large variations in the organic matter may occur without proportionately large increases in the odor components. It is to the credit of the water utility personnel that, in the face of high thresholds in the raw water, finished water odor levels were maintained at the low values shown. Studies conducted in an area where chemical pollution discharges were located near the water intake showed much higher correlation of recovered organic materials and water odor.

3. *Carbon and chlorine dosages.* The carbon applied follows the raw-water thresholds fairly well. Since data on the organic content of the raw water are not available, it cannot be said how much reduction in organic matter occurred as a result of carbon treatment. Threshold reductions are obvious.

Chlorine dosages (free residual treatment) were usually higher at times of recovery of the higher amounts of organics. In one or two instances the chlorine demand of the raw water exceeded the capacity of the equipment to feed the chemical. It would not be expected, however, that chlorine demand would necessarily parallel odorous conditions, since many of the odorous materials may have little chlorine demand. Conversely, high chlorine demanding materials may not be reflected in odor tests. Ammonia falls in the latter category.

Analysis of Chemicals

Once the chemical extracts (chloroform and alcohol) have been recovered, analytical procedures are undertaken to separate major groups of chemicals and, if possible, to identify specific materials. This phase of the work could probably be undertaken only at large, well-staffed water plants. But other avenues are open, and university or private resources are available for conducting the more complicated tests.

Detailed analytical techniques will not be presented here. These procedures are available in a manual (*5*). The usual procedure is to begin with the chloroform extract. By taking ad-

vantage of differences in solubility of various classes of organic compounds, certain broad groups can be isolated: ether insolubles, water solubles, acids, bases, and neutrals.

Use of separation methods and the various analytical devices available can yield much additional information. Ultimate and complete analysis of all components is beyond the scope of most research laboratories. While such analysis may be of interest, it is not generally feasible or warranted.

Some of the principal groups and certain specific materials found in waters by these methods have been discussed recently (*6*). Some of the substances of interest found in water include oily materials, toluene, xylene, DDT, detergents, nitrogen bases such as pyridine and the picolines, nitriles, and various oxygenated compounds such as alcohols, aldehydes, ketones, and esters.

The above discussion is not intended to be an exhaustive treatment of the subject of organics in water. It is intended to point out that waters contain a variety of organic contaminants and that conventional analytical techniques are not measuring the substances. Newly developed techniques are now believed to be ready for use by the water profession. Taste and odor and other problems associated with organic materials in water are expected to increase, hence the water utility man from necessity will have to assess them. This article is meant to serve as a guide for water utility personnel who wish to begin studying these problems.

Summary

Practicable concentration and identification techniques are now available for use by water utilities to assess organic contamination of water not now being measured. Such techniques could provide:

1. A quantitative measure of total organic matter, which would serve as a base line of pollution (Continuous data would indicate pollutional changes.)
2. A measure of the effectiveness of water treatment processes in removing organic contaminants (Threshold tests, of course, are an aid in measuring odor reduction, but tell little of the total remaining materials.)
3. Important clues as to the source and composition of these organic pollutants
4. Organic materials for other tests (Besides taste and odor, organic materials are causing other water quality damage. Such effects include deterioration of ion exchangers, increased chlorine demand, increased carbon demand, and increased coagulant demand. Certainly, these are factors that deserve study. Recovery of materials available for possible physiological studies should not be overlooked.).

For a water plant laboratory to begin studies of organic matter in water, the following could serve as a guide: [1] full awareness by the management and technical staff of the potential problem in their area; [2] details of the equipment needed and of the chemical methods for analysis, which are available in manual form (*5*); and [3] training courses in the techniques of treatment and control, which are given periodically at the Robert A. Taft Sanitary Engineering Center.

Acknowledgment

The kind assistance of Dan Enright and other personnel at the Cincinnati Water Plant in making available records of operation is gratefully acknowledged.

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AMA Reaffirms Safety of Fluoridation

On Dec. 5, 1957, the House of Delegates of the American Medical Association, at its annual clinical meeting, in Philadelphia, adopted a statement to the effect that fluoridation of public water supplies is a safe method of reducing dental decay. The action was taken as a result of a joint study and report by the Council on Drugs and the Council on Foods and Nutrition. The official AMA policy is as follows:

1. Fluoridation of public water supplies so as to provide the approximate equivalent of 1 ppm of fluorine in drinking water has been established as a method for reducing dental caries in children up to 10 years of age. In localities with warm climates, or where for other reasons the ingestion of water or other sources of considerable fluoride content is high, a lower concentration of fluoride is advisable. On the basis of the available evidence, it appears that this method decreases the incidence of caries during childhood. The evidence from Colorado Springs indicates as well a reduction in the rate of dental caries up to at least 44 years of age.

2. No evidence has been found since the 1951 statement by the Councils to prove that continuous ingestion of water containing the equivalent of approximately 1 ppm of fluorine for long periods by large segments of the population is harmful to the general health. Mottling of the tooth enamel (dental fluorosis) associated with this level of fluoridation is minimal. The importance of this mottling is outweighed by the caries-inhibiting effect of the fluoride.

3. Fluoridation of public water supplies should be regarded as a prophylactic measure for reducing tooth decay at the community level and is applicable where the water supply contains less than the equivalent of 1 ppm of fluorine.

Use of Chlorine for Control of Odors Caused by Algae

Ray Harlock and Rae Dowlin

A contribution to the Journal by Ray Harlock, Supt. of Water Treatment, and Rae Dowlin, Operating Engr., both of McNeil Island, Wash. Wash.

THE watershed at McNeil Island, Wash., is forested with second-growth fir and has soil composed largely of clay. A small earth dam 10 ft high and 50 ft long is used to impound the water which runs off the hills and seeps through an alder bog of about 100 acres. Two 1,000-gpm pumps lift the water to the main raw-water reservoir which holds approximately 700 mil gal and has a maximum depth of 40 ft. Seepage from this reservoir is collected in a lower reservoir of approximately 25-mil gal capacity. The bottoms of both raw-water reservoirs are alder bogs and the edges are swampy, with cattails and skunk cabbage growing in profusion.

Water is impounded during the winter months for use during the dry summer. From the middle of June to the middle of September, the problem is the removal of color, iron, manganese, and odors caused by algae. The predominating organism is *Anabaena*.

No attempt is made to control algae in the upper reservoir, but the lower reservoir, under microscopic control, is treated with copper sulfate as needed during the summer. The swampy areas of the impounding reservoir would be uneconomical to drain, and the algae are controlled but not eradicated with regular treatments of copper sulfate.

From the middle of September to the middle of June the problem is simply one of removing the color which is organic material derived from the leaching of ferns in the fall. During the above period, odors are at a minimum. The color, however, must be completely removed if the distribution system is to be kept odor-free. A chlorine residual of at least 0.2 ppm is carried in dead ends. If there is any organic matter in the water leaving the plant, it will first react with the chlorine present, producing a chlorine odor at the cold-water tap. If there is insufficient chlorine to react with all the organic matter present, then bacteria counts will become astronomic, anaerobic conditions will develop, and the water will have a vile swamp taste.

Because of the high organic content of the water, septic conditions develop in the bottom of the reservoir about the first of July. This area has the greatest concentration of iron, manganese, and odors, and is devoid of oxygen. The top 3 ft of the reservoir has the greatest concentration of algae. It is supersaturated with oxygen, and the odors are almost as bad as those from the bottom zone. The top 3 ft also has the greatest chlorine demand. The area with the least odors seems to be at 8 ft below the surface. *Anabaena* appears regularly each year when the

water reaches 14°C and disappears when it reaches 13°C.

Odor Control With Chlorine

Chlorine demand tests are run regularly to give a continuous picture of the demand curve. The water displays a series of plateaus instead of a breakpoint. The plateaus are in the form of an arithmetical progression of approximately 6 ppm frequency. The length of the plateaus is approximately 2 ppm (Fig. 1). The residual is a function of time.

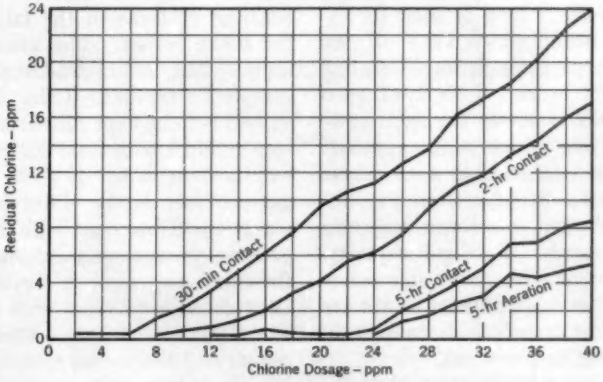

Fig. 1. Typical Chlorine Demand

Demand is a function of time.

In the winter months, the end of the first plateau is chlorinated. Chlorine dosage is determined by odors at the hot-water tap; whenever an odor develops the chlorine dosage is raised to the level of the end of the next plateau. The retention through the plant is approximately 6 hr. If the odor persists after 6 hr, the chlorine dosage is raised to the level of the end of the next plateau, and so on, until there is no odor at the hot-water tap (80°C). With this method, all swamp or algae odors can be destroyed.

There was a decided chlorine odor, however, at the cold-water tap. This odor rapidly disappeared when the water was left standing in an open vessel. Aeration was tried on the finished water and it was found that there was a definite loss of residual chlorine until a constant pH was reached. Beyond this point, the residual was stable and there was no odor of any kind in the water.

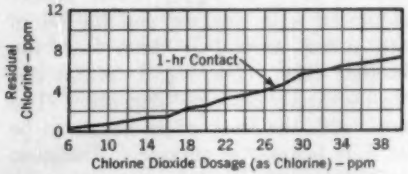

Fig. 2. Chlorine Dioxide Demand

Distilled water free of chlorine demand was then dosed with 10 ppm of chlorine. Aeration gave no reduction in the residual and no chlorine odor could be detected.

Acting on this information, an aerator was installed where the water enters

the clear well. For effective color removal, water has to be filtered at pH 5.8 to 6.4, and aeration raises the pH to 7.4. With aeration, both the carbon dioxide dissolved in the water from the alum reaction and the dissolved gases having the chlorine odor are removed. It has been found that it takes 0.3–0.5 cu ft of air per gallon of water to reach a constant pH. It has also been found that it is much cheaper to aerate the carbon dioxide from the water than it is to neutralize it with lime or soda ash.

Manganese Removal

Manganese was very troublesome during the summer months. In all the literature read, it is stated that the pH must be raised to 9.2 or above in order to flocculate manganese. This was impossible at McNeil Island because water must be filtered at a pH of 5.8 to 6.4 in order to remove the color.

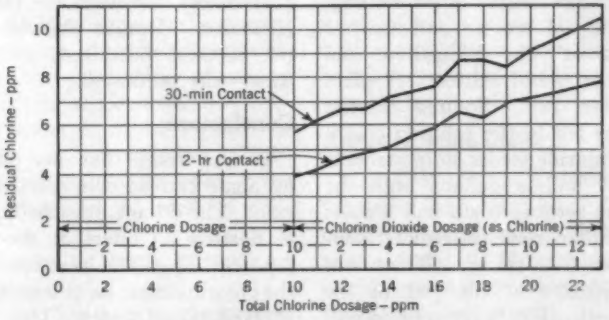

Fig. 3. Demand With Chlorine Dioxide Added to Water Previously Dosed With Chlorine

Chlorine Dosage was 10 ppm.

Tests were also run with sulfur dioxide as a dechlorinating agent. It was found to be successful and very selective, destroying those compounds first that cause the chlorine odor and leaving an odor-free water. Again, with this method, chlorine dosage must be high enough to destroy all odors at the hot-water tap. The contact time with McNeil Island water must be at least 6 hr. Aeration tests were run to see how much chlorine could be aerated from the water, and dechlorination was carried slightly beyond this point. This method was decided against because its reaction produces two more acids in the water that have to be neutralized and because it requires close control and has a higher cost.

The water that leaves the mixing chamber has no color. In past years, it was noticed that any color returning in the settling basin was directly proportional to the amount of manganese in the raw water. Also, noticed was the fact that filter runs were inversely proportional to the amount of manganese in the raw water. The filter effluent, however, had no color. It was apparent that the chlorine was oxidizing the manganese to the colloidal state at which the filters could remove it.

If the chlorine oxidizes the manganese, it does so after the floc has set-

tled, and a stronger oxidizing agent would oxidize it ahead of the mixing chamber. With this in mind, a chlorine dioxide demand test (Fig. 2) was run on the water. It was at once apparent that chlorine dioxide alone would be prohibitive in cost. A demand test was then run in which chlorine dioxide was added to water which had already received the regular chlorine dosage (Fig. 3). The color of the water in the beakers immediately darkened. When the regular dose of alum was added, a floc formed that was burned chocolate in color instead of the usual cream color. After settling, the color did not reoccur and analysis showed that all the manganese had been coagulated and settled. A plant test was then run. Sodium chlorite solution was fed to the solution chamber of the chlorine feeder in increments of 5 lb per million gallons until the water in the settling basin had a color of zero. Filter runs immediately increased from 6 to 60 hr. Water was being chlorinated at the end of the second plateau—100 lb per million gallons—when the feeding of sodium chlorite was begun. Ordinarily, at that time of the year—summer—it is necessary to chlorinate to the end of the seventh plateau—360 lb per million gallons—to get complete odor removal. Throughout the summer there was never any need to raise the chlorine dosage beyond the second plateau. The sodium chlorite dosage varied from 10 lb to 20 lb per million gallons, depending on the amount of manganese present. The average was about 15 lb per million gallons. There was little difference in cost but control of odors was much easier with the chlorine dioxide. Added advantages were the clean filters, long filter runs, and the removal of the manganese in the settling basins.

Toward the end of the season, in order to determine the limits of this system as far as odor removal was concerned, the impounding basin was deliberately allowed to bloom with *Anabaena*. Results showed that with the method described, an odor-free water was produced.

Conclusions

It was found that any odor caused by algae can be eliminated with chlorine. The dosage must be high enough to destroy all odors at the hot-water tap (80°C). The reaction time with the chlorine must be at least 6 hr—with McNeil Island water. This can be reduced by the further addition of chlorine dioxide. The finished water must be aerated to a constant pH. With the water described, it takes between 0.3 and 0.5 cu ft of air per gallon of water. Manganese can be removed with an alum floc at a low pH if it is previously oxidized with the aid of chlorine dioxide.

Defluoridation of Water With Activated Alumina

Emilio A. Savinelli and A. P. Black

A contribution to the Journal by Emilio A. Savinelli, Eng. Service Div., Eng. Dept., E. I. du Pont de Nemours & Co., Wilmington, Del., and A. P. Black, Research Prof. of Chemistry, Univ. of Florida, Gainesville, Fla.

THE presence of the fluoride ion in drinking water may be beneficial or detrimental to public health, depending upon the concentration in which it is found. It is now generally agreed that the optimum fluoride ion concentration for the production of strong teeth in children who continuously consume such water is about 1 ppm. If the fluoride ion concentration is substantially greater than 1.5 ppm, however, it produces in the teeth of children drinking this water regularly a condition known as dental fluorosis or mottled enamel.

The fluoride ion is now recognized, both in this country and abroad, as a normal and frequently occurring constituent of natural waters. The latest figures available indicate that in this country there are over 600 public water supplies serving about 1,500,000 people with water containing this ion in concentrations in excess of 1.5 ppm (*1*). Despite this situation, at the present time, only two communities are known to be using equipment specifically installed for the purpose of removing excess fluorides from their water (*2*). This lack of application of preventive measures may be attributed to a number of factors—most important of which are the high cost and complexity of operation of the fluoride removal processes.

The methods of fluoride removal which have been tried or suggested may be divided into two basic types—those based upon the addition of some material to the water during the softening or coagulation processes and those based upon an ion-exchange or adsorption process.

Additive Methods

Chemical treatment methods include the use of lime either alone (*3*) or with magnesium as dolomitic lime or magnesium sulfate (*4, 5*); magnesia (*6, 7*); calcium phosphate added as a powder (*8, 9*) or precipitated "in situ" (*10, 12*); and aluminum sulfate, alone or in conjunction with a coagulant aid (*4, 13–22*). Other chemicals such as the bentonites, fuller's earth, diatomaceous earth, silica gel, bauxite, sodium silicate, sodium aluminate, and ferric salts have also been tried (*3, 23–25*). To obtain appreciable removal with any of these materials, however, requires very low pH (less than 3.0) or excessive quantities of material.

Adsorption Materials

The materials used in contact beds include processed bone (*26, 27*), activated carbon (*28*), magnesia (*29, 30*), tricalcium phosphate or hydroxyapatite (*7, 31–36*), trimagnesium phosphate (*36, 37*), natural and synthetic ion-

exchange materials (*38–47*), and activated alumina (*3, 48–54*). Contact beds have also been prepared by reacting a number of compounds, including sodium silicate, barium chloride, sodium phosphate, ferrous sulfate, or titanium chloride with an excess of aluminum ions, thereby forming insoluble materials which have some fluoride-removing capacity (*55*).

All of the materials developed for use in contact beds up to the present time, however, possess one or more serious drawbacks: low capacities, difficult or expensive regeneration, high initial cost, and lack of selectivity toward the fluoride ion so that much of the capacity is wasted removing other anions.

Installations

The first two full-scale defluoridation plants were constructed at Climax, Colo., in 1937, and at Scooba, Miss., in 1940 (*2*). Both employed contact beds of synthetic hydroxyapatite. The process was unsuccessful and both plants have since been abandoned. A plant employing the same process was built at Britton, S.D., in 1948, but attrition losses were so high—amounting to as much as 42 per cent of bed material per year—that the synthetic material was replaced by bone char in 1953. Using a caustic soda–carbonic acid regeneration, the material appears to have an exchange capacity of about 450 grains (gr) of the fluoride ion per cubic foot of bed when removing about 5 ppm of the fluoride ion.

Recently, a small plant employing bone char was constructed at Camp Irwin, Calif., where the fluoride ion concentration of the raw water is about 10 ppm (*56*). When exhausted, the bone char is regenerated with caustic soda and phosphoric acid. Chemical costs, however, make this method prohibitive for all situations save those where no other supply is available. At Bloomingdale, Ohio, the fluoride ion is being successfully reduced from 2.2 ppm to 1.2 ppm by the lime-soda softening of a water containing considerable magnesium (*5*). This process offers much promise for such waters although it is not adaptable to waters containing more than 3–4 ppm of the fluoride ion.

After pilot plant studies at Bartlett, Tex., a full scale plant was constructed in that city in 1952, based upon the use of a 500-cu ft bed of activated alumina regenerated with caustic soda and sulfuric acid (*2*). It was placed in operation in Mar. 1952, and is believed to be the most successful and advanced plant now in operation.

Early Methods

The use of a bed of aluminum oxide for the removal of the fluoride ion from drinking water appears to have been first suggested by C. S. Boruff (*3*) in 1934. He also suggested that after the fluoride-removing capacity of the aluminum oxide was exhausted, it could be regenerated with a 2 per cent solution of sodium hydroxide, followed by neutralization of the excess alkali with dilute hydrochloric acid. Calculations based on the data presented in the article indicate that the capacity of the aluminum oxide used was about 295 gr of the fluoride ion per cubic foot of alumina. Several patents based on the use of aluminum oxide for fluoride removal were issued to Meinzer (*49*) and Churchill (*50*) in 1936, Goetz (*52*) in 1938, and Urbain and Stemen (*53*) in 1940.

Meinzer's patent (*49*) was based upon the idea that aluminum hydroxide could be precipitated in a bed of sand

or diatomaceous earth by saturating the bed with aluminum sulfate and then passing a solution containing alkali through the bed, thereby coating the surface of the particles in the bed with a very thin layer of aluminum hydroxide. No method is given for the regeneration of the material once the capacity of the bed is exhausted.

The patent issued to Churchill (*50*) specifically mentioned the use of activated alumina as contrasted with ordinary aluminum oxide, the alumina being activated by heating to a temperature of 400–500°C in the presence of alkali metal ions. It is stated that the material can be regenerated, after its fluoride capacity has been exhausted, by washing with either acid or alkali or both. No data are presented about the capacity of the material treated in this manner.

Also in 1936, Fink and Lindsay (*48*) published an article which discussed the use of specially prepared activated alumina for fluoride removal. The authors suggested the use of small home units for fluoride removal, with the material to be discarded after its capacity had been exhausted. From the data presented, the capacity of the material was calculated to be about 416 gr of the fluoride ion per cubic foot of alumina.

The following year Swope and Hess (*51*) reported on the use of an activated alumina *—prepared according to Chuchill's patent (*50*)—for the removal of fluorides from drinking water. These authors suggested regenerating this material with a 5 per cent sodium hydroxide solution followed by neutralization with a 0.35 per cent solution of hydrochloric acid. From the data presented, the exchange capacity of this product was calculated to be about 505 gr of the fluoride ion per cubic foot of material.

Goetz's patent (*52*) was based upon a modification of the regeneration process for the activated alumina where, following the alkali rinse which he states is necessary to remove the fluoride ions picked up in the previous cycle, the bed is conditioned with a mixture of an acid plus an acid salt or, in some cases, an acid salt alone. The capacity of the activated alumina subjected to this treatment was reported to be about 600 gr of the fluoride ion per cubic foot of alumina.

Urbain and Stemen (*53*) based their patent claims on a process in which any sorptive material could be soaked in a concentrated solution of any aluminum salt for a period of approximately five hours. They claim that by this conditioning a number of sorptive materials, including activated alumina, can be made to have appreciable fluoride-removing capacity, but no data are given with respect to capacity or regeneration efficiency.

As mentioned previously, Maier (*2*) chose the method first proposed by Boruff—in which the water to be treated is passed through a bed of activated alumina—for a full-scale plant at Bartlett, Tex. When the capacity of the alumina is exhausted, the material is treated with a 1 per cent solution of sodium hydroxide, followed by a rinse with treated water to wash out most of the remaining alkali. A dilute solution (0.05 *N*) of sulfuric acid is then passed through the bed to neutralize any remaining alkali and the bed is finally rinsed again with treated

* A product of the Aluminum Company of America, New York, N.Y. Behrman and Gustafson developed a product—given an identical name—which consisted essentially of hydroxyapatite and which was also regenerated with sodium hydroxide.

water before being restored to operation. Maier states that the capacity of the alumina in this installation is about 514 gr of fluoride ion per cubic foot of material when removing 7 ppm of the fluoride ion.

Present Investigation

During an exhaustive screening program carried out by the investigators, it was found that a dilute solution of aluminum sulfate alone could be used to regenerate activated alumina. It was also found that when the alumina was regenerated in this manner it had an appreciably higher fluoride exchange capacity than when treated by any of the previously mentioned methods. Consequently, an investigation was begun of the use of aluminum sulfate for this purpose. The effects of the following factors upon the capacity of the alumina have been studied:

1. Quantity of aluminum sulfate used during regeneration
2. Concentration of aluminum sulfate solution used during regeneration
3. Flow rate of aluminum sulfate solution during regeneration
4. Flow rate of water being treated during exhaustion
5. Concentration of fluoride ion in water being treated
6. Concentration of the chloride, sulfate, bicarbonate, and hydrogen ions in water being treated.

The study also included an exploratory investigation of the mechanism involved in the exhaustion and regeneration phases of the exchange cycle.

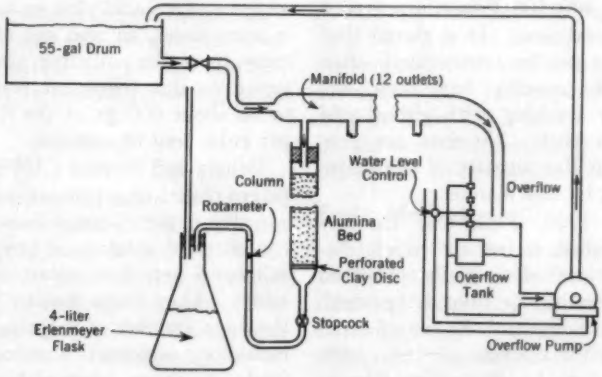

Fig. 1. Schematic Diagram of Apparatus Used in Study

Column shown represents one of twelve used.

Apparatus

Apparatus for the study is shown in Fig. 1. The columns containing the beds of activated alumina were constructed from 1-in. glass tubing, each 24 in. long. The bottom of each tube was drawn and joined to a ground-glass stopcock used to control the flow of water through the column. Just above the point where the tube was drawn, a perforated clay disc was welded to support the bed of alumina. The flow through the column was measured by a rotameter connected to

the stopcock by rubber tubing. The discharge from the rotameter was collected in either a 4-liter Erlenmeyer flask or a calibrated 5-gal carboy, depending upon the amount of water to be collected between analyses.

The water to be treated was prepared in a 55-gal drum and distributed through a manifold to the 12 columns attached. The manifold had an open connection at one end which permitted a slow stream of water to overflow, producing the effect of a constant head

TABLE 1

Typical Analysis of Tap Water Used to Exhaust Beds *

Constituent	ppm
Total dissolved solids	132.0
Silica (SiO_2)	17.0
Iron (Fe)	Trace
Calcium (Ca)	17.0
Magnesium (Mg)	3.6
Sodium and potassium (Na, K)	22.0
Bicarbonate (HCO_3)	58.0
Sulfate (SO_4)	43.0
Chloride (Cl)	19.0
Fluoride (F)	10.0
Nitrate (NO_3)	Trace
Total hardness	57.0
pH	8.5

* Fluoride added.

device. The overflow was collected in a tank and automatically returned to the 55-gal drum.

Experimental Procedure

The basic procedure in all the experiments was essentially the same. Although twelve columns of alumina were available, the number of columns used for any one experiment depended upon the data being collected. In many cases, pairs of columns were run in an identical manner in order to check the precision of the results. Before any of the test data were collected, all the activated alumina used was conditioned by passing it through at least ten complete cycles of regeneration with aluminum sulfate and exhaustion with water containing 10 ppm of the fluoride ion.

The flow rate during regeneration, unless otherwise stated, was 5.5 ml per minute. This meant that approximately 6 hr was required for the 2 liters of solution usually used for regeneration to pass through the column. After regeneration, the columns were

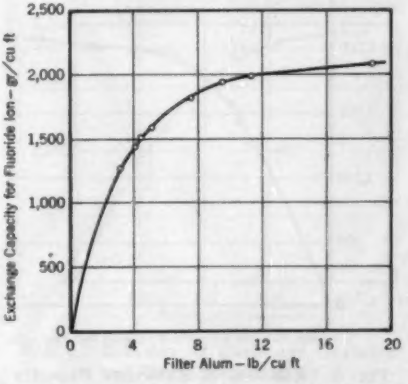

Fig. 2. Relation of Exchange Capacity and Regeneration Level

backwashed for 30 min with distilled water at such a rate as to cause at least 100 per cent expansion of the bed. During the exhaustion phase, the water used to exhaust the beds contained 10.0 ± 0.1 ppm fluoride ion and was passed through the beds at a flow rate of 28 ml per minute unless otherwise noted. An analysis of this water is given in Table 1.

Results

The first variable studied was the effect of regeneration on exchange ca-

pacity. Figure 2 shows exchange capacity as a function of regeneration level. From this curve, it can be seen that the capacity of the alumina for the fluoride ion increases rapidly with the amount of filter alum used for regeneration up to a maximum of about 2,000 gr per cubic foot at a regeneration level of 12 lb of filter alum per cubic foot. Beyond this point, the increase in capacity is very slight, even with large increases in the amount of filter alum used.

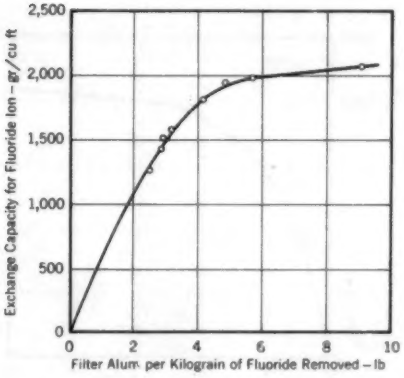

Fig. 3. Relation of Exchange Capacity and Regeneration Efficiency

Figure 3 shows the exchange capacity as a function of regeneration efficiency. This curve shows that for exchange capacities up to about 1,500 gr per cubic foot, the amount of filter alum required per kilograin of fluoride removed is practically constant at about 2 lb per kilograin. Beyond this point, the regeneration efficiency decreases rapidly.

Once the exchange capacity for various amounts of regenerant was established, the next step was to determine the effect of concentration of regenerant solution on exchange capacity. This was done by using a constant amount of filter alum per column but varying within wide limits the volume of water in which it was dissolved. The data presented in Fig. 4 show that for solutions ranging from 1 to 10 per cent by weight of filter alum, the concentration of the regenerant has little or no effect on the exchange capacity of the alumina.

The next variable to be studied was the effect of the exhaustion flow rate on exchange capacity. The data presented

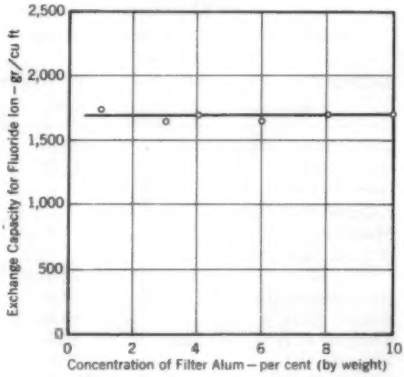

Fig. 4. Relation of Exchange Capacity and Regenerant Concentration

in Fig. 5 show that for flow rates of 0.5–2.0 liters per hour, there is little change in exchange capacity, but that when the flow rate is raised above 2 liters per hour, the exchange capacity of the alumina decreases.

An interesting point was brought out in the study concerning the effect of time of regeneration on exchange capacity. Although there is little effect on capacity over a wide range of flow rates during the exhaustion process, the time of contact of the alumina with filter alum during regeneration plays a significant part in the exchange ca-

pacity of the material. The data presented in Fig. 6 show that for the same regeneration level, the exchange capacity of the alumina ranges from about 600 gr per cubic foot for a regeneration time of 1 hr to about 1,750 gr per cubic foot for a regeneration time of 4 hr. For contact times of more than 4 hr, the increases in exchange capacity were small.

The data presented in Fig. 7, showing exchange capacity as a function of the fluoride ion concentration of the influent water, indicate that there is a linear relationship between exchange capacity and fluoride ion concentration. This relationship, however, is not as direct as it appears, because, as was shown by further work, the alkalinity of the influent water also plays an important part in the process. In Fig. 8, which shows exchange capacity as a function of the alkalinity of the influent water, it is seen that as the alkalinity of the influent water increases, the capacity of the bed to remove the fluoride ion decreases. Thus, it is apparent that the alkalinity in the water is competing with the fluoride ion in the exchange process. Figure 9, which shows the effect of pH of the influent water on fluoride exchange capacity of the alumina, reflects once more the role that alkalinity plays in the removal process. From this curve, it can be seen that when the pH of the influent water is lowered to 5.6 with acid, the capacity of the alumina to remove the fluoride ion increases to about 3,400 gr per cubic foot. Thus, it can be seen that the neutralization of the alkalinity in the water is immediately effective in substantially increasing the capacity of the alumina for the fluoride ion.

The last variable to be studied which affected the exchange capacity was the effect of high concentrations of the sulfate and chloride ions. Very little effect on exchange capacity was found with concentrations of either of these ions up to 1,000 ppm.

The changes that occur in the concentrations of the various ions during a typical cycle of regeneration and exhaustion are of interest. As shown in Fig. 10, one such point brought out during the exhaustion process was the relationship that could be established between the concentration of the sulfate ion in the effluent and the amount of fluoride and bicarbonate ions removed. It will be noted that there is

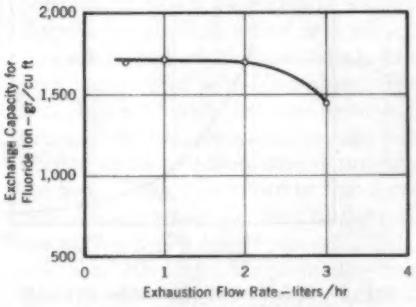

Fig. 5. Relation of Exchange Capacity and Exhaustion Flow Rate

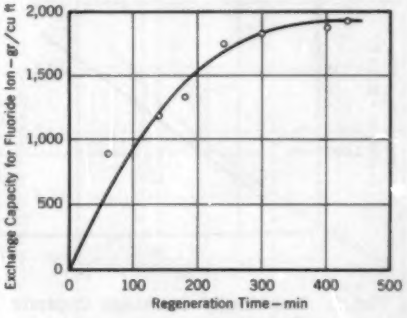

Fig. 6. Relation of Exchange Capacity and Regeneration Time

appreciably more sulfate in the effluent (about 160 ppm at the start) than there was in the influent water (about 40 ppm). The same figure shows that as the alkalinity and fluoride ion concentration of the effluent increase, the sulfate ion concentration decreases. When these changes are calculated on a milliequivalent basis, it is found that the sum of the milliequivalents of the fluoride and bicarbonate ion removed is approximately equal to the milliequivalents of the sulfate ion released during the exhaustion phase. This fact is important in explaining the mechanism of the exchange process discussed later.

The changes in concentration of the other ions are not very significant and, therefore, they will be discussed only briefly. As might be expected, the pH of the effluent is low during the time the alkalinity is being removed, but increases as the concentration of alkalinity increases in the later stages of the run. The shape of the curve showing the fluoride ion concentration throughout the run is interesting in that the fluoride removal efficiency improved during most of the run and did not reach a maximum until about 75 per cent of the water has been treated. For alkalinity, just the opposite effect is observed. The curve shows that all the alkalinity is removed during the first half of the run and that the amount left in solution increases rapidly during the remainder of the run. Total hardness decreased about 25 per cent in the early stages after which it leveled off and remained practically constant for the remainder of the run. Essentially no change occurred in the chloride ion concentration as it passed through the bed.

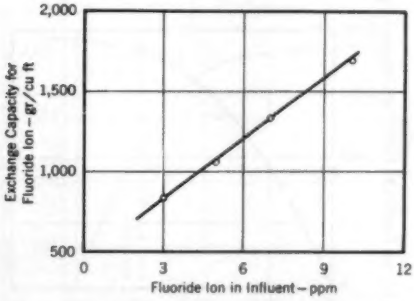

Fig. 7. Relation of Exchange Capacity and Fluoride Ion Concentration in Influent

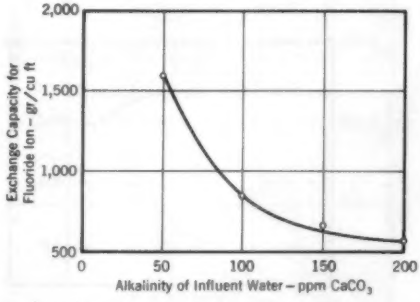

Fig. 8. Relation of Exchange Capacity and Alkalinity of Influent

A surprising observation made during the regeneration process was that the first and second 500-ml portions of regenerant that had passed through the bed were crystal clear, while the third and fourth portions contained appreciable amounts of precipitate. Later analyses revealed that the first two portions were high in alkalinity and low in fluoride, and had practically no aluminum present, while the last two had large amounts of aluminum, an appreciably greater fluoride ion concentration, and no alkalinity. Also, the sulfate concentration of the first 500-ml portion was very low but the next three portions were found to contain increasing amounts of this ion.

Implications

These data suggest a possible mechanism for the removal of the fluoride ion by alumina and the subsequent regeneration of the alumina with filter alum. Considering the exhaustion phase of the process first, the approximate milliequivalent balance which could be established between the quantity of sulfate ion released into the water and the quantity of fluoride and bicarbonate ion removed gives strong evidence that the mechanism occurring is one of ion exchange. This idea is further supported by the results of an experiment in which a solution of sodium fluoride in distilled water was passed through a bed of alumina which had been regenerated with filter alum. Although the fluoride ion was removed, the sodium ion concentration did not change as the solution passed through the bed. Thus, it is apparent that a cation was not removed with the fluoride ion during the exchange process. This, of course, eliminates the possibility that the process is one of physical adsorption.

In the regeneration process, however, the data available indicate that the cation associated with the sulfate ion does play an important part in regenerating the alumina. This idea is further supported by the results of attempts to regenerate the alumina with sulfuric acid and with sodium sulfate. When sulfuric acid was used as the regenerant, the regeneration pattern was the same as was found for filter alum. During the first half of the regeneration the effluent was crystal clear after it passed through the bed, but during the second half of the regeneration, an appreciable amount of flocculant aluminum hydroxide was present. Also, data for the capacity of the alumina after treatment with sulfuric acid indicated that it was approximately equivalent to that for a regeneration with a comparable amount of filter alum. The entire effluent from the sodium sulfate regeneration, however, was clear and, after regeneration, the alumina exhibited little or no capacity for the fluoride ion. Thus, it appears that the aluminum ion is necessary to effect the exchange between the sulfate ion and the fluoride and bicarbonate ions in the bed. In the sulfuric acid regeneration, the aluminum ions were

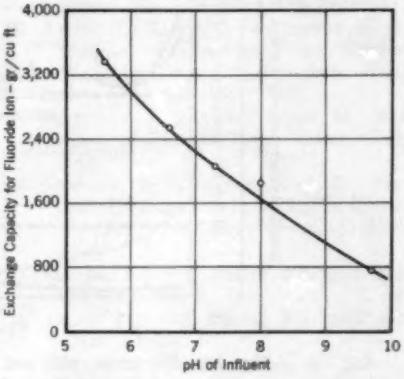

Fig. 9. Relation of Exchange Capacity and pH of Influent

supplied by the alumina that was dissolved by the acid. The exact role played by the aluminum ion is not known at present. It may be one of complex ion formation or neutralization of part of the alkalinity released, or both, with the resultant formation of microflocs of aluminum hydroxide. The fact that little aluminum sulfate was found in the first part of the regenerant solution, after it had passed through the bed, further supports the above ideas if the sorptive properties of alumina are considered. On this

basis, sulfate ions are removed from solution by exchange for fluoride and bicarbonate ions, while aluminium ions or flocs are held in the bed by adsorption and then released during the later stages of regeneration.

Summary

The salient points brought out during the course of this work were:

1. Activated alumina regenerated with filter alum may be used to remove fluorides from drinking water.

2. The exchange capacity of the alumina was found to be proportional to the amount of filter alum used for regeneration up to a regeneration level of about 12 lb of filter alum per cubic foot of alumina. At this level, the fluoride exchange capacity was approximately 2,000 gr per cubic foot.

3. The most important single factor affecting the fluoride exchange capacity of the alumina was the alkalinity of the influent water.

4. The exchange capacity of the activated alumina was essentially independent of both the concentration of the regenerant solution and the exhaustion flow rate—within the limits set by practical operation.

5. The mechanism by which the fluoride ion is removed from water by activated alumina regenerated with filter alum is most likely one of ion exchange.

Acknowledgment

This investigation was supported by a research grant from the National Institute for Dental Research of the National Institutes of Health, USPHS.

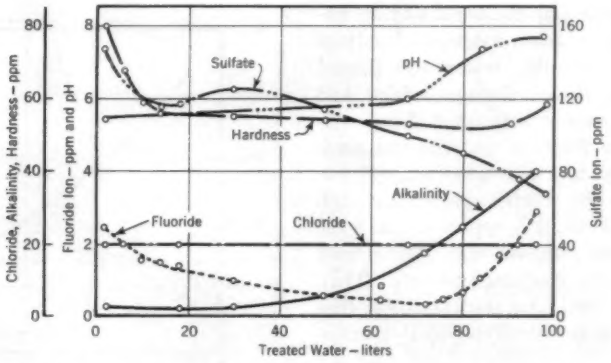

Fig. 10. Hardness, pH, and Concentrations of Various Ions During Typical Exhaustion Phase

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Cost of Water Treatment in California

Gerald T. Orlob and Marvin R. Lindorf

A contribution to the Journal by Gerald T. Orlob, Asst. Prof. of Civil Eng., and Marvin R. Lindorf, Graduate Student (Harry E. Jordan Scholarship Award, 1956), both of the University of California, Berkeley, Calif.

AS a direct consequence of a phenomenal population increase in the last decade, California is now faced with an acute water shortage. Many underground supplies have been drastically overdeveloped, and surface supplies are being sought at increasing distances from the areas of consumption. The California Water Plan (*1*), the state's comprehensive plan for full development of its water resources, calls for the transporting of water more than 600 miles from northern areas of water surplus, through an extensive system of channels, conduits, pumping stations, and reservoirs, to the water-deficient areas of Southern California. This water would be delivered in the Los Angeles area for total project costs ranging upward from $45 per acre-foot. Since the quality of this water at the points of diversion is exceptionally high, it has been presumed that treatment will be minimal. It is not difficult to imagine, however, that some treatment beyond chlorination will be required, in view of the transport distance and the necessity for storage of water in reservoirs along the route or near the area of consumption. Perhaps filtration and chlorination alone will suffice to produce satisfactory water. Or, in the extreme, complete water treatment including flocculation, sedimentation, filtration, and chlorination may become the rule.

In the event treatment of these waters does become necessary, it would be useful to know what the costs will be and what relationship they will bear to the costs of surface water importation, reclamation of waste waters, ground water recharge, or any of the other techniques considered for easing California's water problems. This article presents the results of an investigation of the costs, construction, and operation of complete water filtration facilities in the state of California. Data were collected and analyzed for 32 treatment facilities, serving approximately 3,550,000 persons, or about 27 per cent of the state's 1956 population.

Cost Indexes

A number of construction cost indexes are available to engineers, but most of these are too general to be applicable to such a specialized item of construction as a water filtration plant. For example, the *Engineering News-Record* construction cost index, probably most widely employed of all, simply prices 2,500 lb of structural steel shapes, 1,088 fbm of 2 × 4, S4S lumber, 6 bbl of Portland cement, and 200 hr of common labor.

Recently, several attempts have been made to improve methods of translating past costs to present dollar values. For example, Fick (*2*), combined various published indexes to reflect cost

changes in the individual components of a water works property. The cost trend curve for the entire property was obtained by weighting the individual components in proportion to their separate costs. Although Fick's method has merit in application to the total water works property, it seems too general for reliable application to a water filtration plant.

A more specific series, the Handy-Whitman Index of Water Works Property Construction Costs,* has been offered (*3*). Indexes have been prepared for 29 different water works property items for each of six geographic divisions of the United States. Included in this series are indexes for large and small treatment plants.

Even before the Handy-Whitman index was published, the authors decided to develop a water treatment plant index which could be readily synthesized from data on unit costs published in *Engineering News-Record*. In order to determine the weighting factors for the various components of the index, a detailed study was undertaken based on the material breakdown and construction practices on a newly constructed water filtration plant. The unit chosen was the 6-mgd Oakley water filtration plant designed by R. E. Ramseier and Associates of Berkeley, Calif., and placed in operation by the Oakley County Water District, Calif., in January 1957.

Inspection reports covering the progress of work provided detailed accounts of the number of man-days of each type of skilled and common labor, the work undertaken and completed daily, and the equipment used. The engineer's and contractor's cost estimates and the plans and specifications for the job are also available and provided additional sources of information.

On-the-job labor for the Oakley treatment plant totaled approximately 4,135 man-days, including 192 days of supervision, 2,848 days of skilled and semiskilled labor, and 1,095 days of common labor. The weighted-average wage rates, including allowances for social security, state and federal unemployment insurance, vacation and welfare funds, were $2.52 per hour for common labor and $3.57 per hour for skilled and semiskilled labor. Common labor accounted for approximately 20 per cent of the contractor's expenditure for on-the-job labor exclusive of supervision. Table 1 presents a de-

TABLE 1

Labor Breakdown, Oakley Water Filtration Plant

Labor Operation	Working Time *man-days*	Hourly Rate* $
Supervision	192	
Common labor	1,095	2.52
Plumbing and pipe fitting	768	3.96
Carpentry	747	3.42
Electrical	223	4.02
Reinforcing-steel installation	203	3.19
Crane and dragline	172	3.76
Painting	151	3.34
Cement finishing	140	3.92
Structural iron work	136	3.48
Bulldozer operation	82	3.76
Masonry	59	4.14
Truck driving	42	2.58
Steel form erection	39	3.48
Fence erection	20	3.48
Plastering	16	3.93
Floor laying	8	3.45
Sand blasting	8	2.97
Roofing	4	3.33
Sheet metal work	4	3.65
Glazing	2	3.02
Ceiling finish	2	3.37

* Includes allowances of 15–20 per cent over base rate for social security, state and federal unemployment insurance, vacation and welfare funds.

* Published by Whitman, Requardt & Associates, Baltimore, Md.

tailed breakdown of on-site labor requirements for the Oakley plant.

A careful analysis of construction materials was made to determine the proportion of each of several basic types which are normally included in water treatment plant construction. Selected for inclusion in the cost index were ready-mix concrete, reinforcing steel, structural and form lumber, and cast-iron pipe. An analysis of the engineer's estimate for the Oakley plant indicated that the cost of the structural elements comprised approximately 38

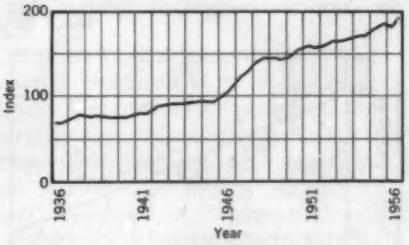

Fig. 1. Construction Cost Index

Based on construction costs for water treatment plants in the Pacific Coast States, the index is adjusted to March 1946.

per cent of the total plant cost, while the cost of the pipe work amounted to 24 per cent; mechanical equipment, 24 per cent; electrical equipment, 5 per cent; and site preparation, 9 per cent. Mechanical and electrical equipment costs were considered as including off-site subcontract labor costs.

The total cost of construction exclusive of overhead and profit, which were considered proportional to the cost of the project, was taken as proportional to an index consisting of the following items: [1] 120 hr of skilled labor (average of carpenters, electrical workers, and structural-iron workers); [2] 40 hr of common labor; [3] 10 cu yd of ready-mix concrete (50-cu yd lots, delivered); [4] 1,500 fbm of Douglas fir, 2 × 4 S4S (fob carload lots); [5] 1,500 lb of reinforcing steel (new billet, 5-ton carload lot); [6] 1 ton of cast-iron pipe (6–24 in.); and [7] the Marshall and Stevens equipment cost index. The first six items included in the index are readily obtainable from *Engineering News-Record* for each of 20 major cities in the United States from about 1930 to date. The Marshall and Stevens Industrial Cost Indexes on comparative equipment costs have been published since 1913.*

The water treatment plant index for the Pacific Coast States, adjusted to March 1946, was computed for the period 1936–56 and is shown graphically in Fig. 1. It was used in adjusting all construction cost data employed in this study.

The water treatment plant index generally shows a lower projected cost than the EN-R Construction Cost Index. For example, the 1956 cost on an 8-mgd plant constructed in 1937 for $360,000 is set by the water treatment plant index at $905,000. The EN-R index gives a 1956 cost for this plant of $1,075,000.

Construction Cost

In estimating the initial cost of construction as a function of design capacity only those plants providing complete treatment were used. Complete treatment was defined as including at least flocculation, sedimentation, rapid-sand filtration, and chlorination. Aeration or special chemical treatment, such as softening or taste and odor control, were not common to all plants. Although these processes may account for some capital-cost differences among the various plants, the differences were

* Published by Marshall and Stevens, Inc. of Illinois, Chicago, Ill.

considered as relatively small when compared to the inherent variations in the raw data.

With the use of information from only those plants for which reliable data were available Fig. 2 was prepared. Although there is no theoretical basis for selection of the log-log form of the plot, it is apparent that a convenient fit of the data is obtained by a straight line whose equation in the Cartesian system is:

$$C_c = 257\ Q_n^{0.67} \quad \ldots\ldots (1)$$

where C_c is the total capital cost of a complete water treatment facility, Q_n is the design capacity of the plant in million gallons per day to be reached in n years, and the constants are characteristic of the time and geographical location of the construction. Although there is considerable scatter of data about the statistical line of best fit in Fig. 2, the standard error in an individual cost estimate is small considering the inherent opportunities for deviation in construction practices, availability of materials, geographical location, and the labor market.

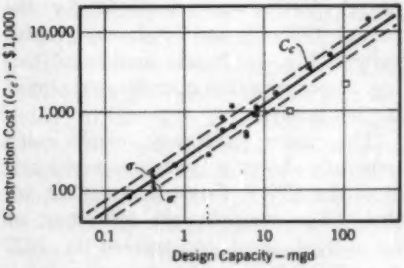

Fig. 2. Construction Costs of Treatment Plants

Data are represented by Eq 1 in the text, using 1956 as the base year. Squares indicate two plants designed for filtration and chlorination only.

As an example of the use of Fig. 2, suppose it is desired to estimate the cost of construction of a 10-mgd water filtration plant. From the figure it can be seen that the most probable cost of such a plant is about $1,220,000 and that there are about two chances in three that the cost will be within the range of $870,000 and $1,640,000.

Also shown in Fig. 2 are construction cost–capacity data for two large treatment plants of the East Bay Municipal Utility District, Oakland, Calif., which employ only filtration and chlorination as basic processes. Although the data are meager, it appears that the omission of flocculation and sedimentation facilities reduces the overall plant cost by about 50 per cent.

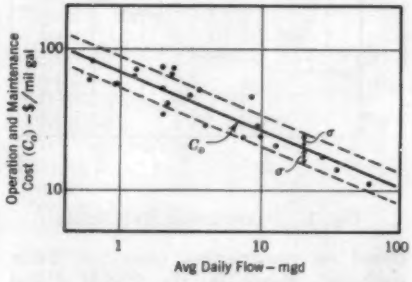

Fig. 3. Operation and Maintenance Costs

Data are represented by Eq 2 in the text, with 1956 as the base year.

Operation and Maintenance Cost

Considerable information was obtained on the operating costs of existing facilities in California. Some older plants for which good construction cost data were not available nevertheless provided accurate up-to-date operation cost figures. These data are presented in Fig. 3 where the line of best fit has the equation:

$$C_o = 68.4\ Q_n^{-0.41} \quad \ldots\ldots (2)$$

in which C_O is the cost of operation and maintenance (including labor, chemicals, power, and plant overhead, but not the cost of purchasing raw water), Q_a is the average daily flow in million gallons per day, and the constants are characteristic of time and geographic location.

Operation and maintenance costs for a typical 10-mgd plant operating at 70 per cent of capacity are estimated from Fig. 3 at \$30.80 per million gallons, and the range of one standard error (logarithmic scale) is \$23.80 to \$39.

Total Cost

In order to determine the total cost of water treatment it is necessary to express the costs of construction and operation and maintenance in identical terms. For purposes of comparison with the reported figures on cost of water development, transport, and reclamation it is convenient to express the cost of treatment on a per million gallon basis.

It is expected that a newly constructed treatment plant will begin operation at some flow, Q_0, and will treat the design flow, Q_n, after a period of n years. If, during the design period, the rate of increase in flow is substantially uniform the equivalent daily water production, Q_E, to be used in determining the unit cost of capital recovery, may be expressed as:

$$Q_E = \left\{ R + (1 - R) \times \left[\frac{1}{n} + \frac{1}{ni} - \frac{F - i}{i} \right] \right\} Q_n \quad . . (3)$$

R is a growth ratio, $Q_0 : Q_n$, and F is the capital recovery factor based on an interest rate of i over a recovery period of n years. The cost of capital recovery in dollars per million gallons for a plant of design capacity, Q_n, is then obtained from Eq 1 and 3:

$$C_R = 704\, Q_n^{-0.33} \left[\frac{F}{Q_E/Q_n} \right] \quad . . (4)$$

The term in brackets is a function of the ratio, R, the interest rate, and the capital recovery period and can be readily evaluated with the aid of standard interest tables.

The assumption that Q_E in Eq 4 is the simple average of Q_0 and Q_n would result in an underestimation of the unit cost of capital recovery.

The average cost of operation and maintenance over a capital recovery period of n years is defined as:

$$C_O = \frac{1}{n} \int_0^n 68.4\, Q_a^{-0.41}\, dt \quad . . . (5)$$

If Q_a is expressed in terms of Q_0 and Q_n the following expression results:

$$C_O = \frac{68.4\, Q_n^{-0.41}}{n} \times \int_0^n \left[R + \left(\frac{1 - R}{n} \right) t \right]^{-0.41} dt \quad . . (6)$$

Evaluation of the integral requires a numerical or graphical method. However, the error in approximating the integral with the ordinate at the middle of the recovery period times the length of the period is usually less than 2 per cent, a simplification which is probably justified in view of the method by which Eq 2 was determined.

Adding Eq 4 and 6 produces an expression for the probable total cost of water treatment as a function of the design capacity, the growth ratio, the rate of interest, and the capital recovery period:

$$C_T = 704\, Q_n^{-0.33} \left[\frac{F}{Q_E/Q_n} \right] + \frac{68.4}{n}\, Q_n^{-0.41} \times \int_0^n \left[R + \left(\frac{1 - R}{n} \right) t \right]^{-0.41} dt \quad . . (7)$$

This expression is plotted in Fig. 4 for $n = 20$, $i = 0.05$ and values of R of 0.4, 0.7, and 1.0. The resulting curves are closely approximated by equations of the same general form as Eq 1 and 2, in which the exponent is about -0.37 and the coefficient ranges from 124 for $R = 1.0$ to 164 for $R = 0.4$. The dashed curves shown in Fig. 4 indicate the effect on total cost of water due to changes in the period of capital recovery.

From Fig. 4 it can be seen that the probable average cost of water for a 10-mgd plant, presently operating at 70 per cent of capacity and capitalized at 5 per cent interest for 20 years, is about \$60 per million gallons. According to statistical theory the standard error in this value should be:

$$\sigma_T = \sqrt{\sigma_R^2 + \sigma_O^2} \quad \ldots\ldots (8)$$

which would indicate a range of \$38.20 to \$94 for a probability of about two-thirds. Actually the two sets of data on which Eq 1 and 2 are based are not statistically independent, and the range is probably somewhat narrower.

Comparative Costs

The significance of expenditures for conventional water treatment can best be seen when such costs are contrasted with costs of developing new supplies, transporting water to areas of use, or producing potable water from sea water or domestic and industrial waste waters.

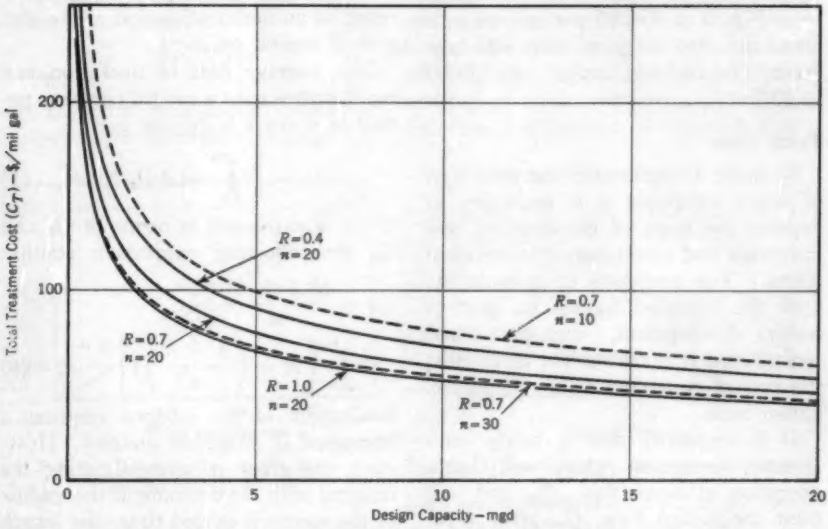

Fig. 4. Examples of Total Treatment Costs

Curves are plotted from data obtained with Eq 7, with 1956 as the base year. R *is a growth ratio of* $Q_0:Q_n$*;* n *represents the capital recovery period (in years); and the interest rate* (i) *is constant throughout, at 0.05. Solid curves indicate the effect of a changing* R*; dashed curves the effect of a changing* n.

Ground water. In many areas of California, notably the Central Valley, the cheapest water satisfactory for direct delivery to distribution systems is obtained from wells. The average cost

of delivering ground water to typical small irrigation units through a 100-ft lift in 1956 was estimated by Sorter (*4*) at $4.73 per acre-foot, or about $14.50 per million gallons. In a discussion of Sorter's article, Blaney cites data for five mutual water companies whose costs ranged from $6.40 to $25.50 per acre-foot per 100 ft of lift at 6 per cent interest in 1954. An average cost of about $40 per million gallons is indicated from these data.

The use factor (the ratio of actual pumpage to theoretical continuous pumpage) for municipal pumping probably averages more than twice the use factor for irrigation pumping. Assuming that power costs account for approximately 50 per cent of total pumping costs, the cost of ground water delivered to a municipal system is estimated to range from about $15–$30 per million gallons for a 100-ft pumping lift. This estimate is reasonably compatible with the reported cost of $30–$70 per million gallons for water from the domestic systems of several Central Valley cities (*5*) when account is taken of cost of operation, maintenance, and capital recovery of the distribution system.

The unit costs of ground water delivered to the system appear to be somewhat independent of the capacity developed because of the limitations imposed by pumping equipment and well drilling techniques. Also, the total cost of ground water, since it depends heavily on power cost, shows little correlation with the trends in construction cost. In the Central Valley steadily declining power rates over the past 30 years have compensated for the increase in construction costs with the result that total costs of ground water have either remained steady or have slightly declined. Assuming that potable water for a given city can be obtained from either surface or ground water sources, it appears that based on 1956 costs complete water filtration is not likely to be a competitive alternative until a capacity of about 60 mgd is required (C_T = $30 per million gallons).

Surface water. The cost of developing surface supplies is determined primarily by the quality and quantity of the water available or desired by the consumer and the distance over which the water must be transported. Sometimes an investment in development of a remote source not requiring treatment can be economically justified. With the growing demands for water brought about by increasing population and industrial growth, however, and the scarcity of supplies that can be developed, it is well to give consideration to upgrading water of lesser quality by means of conventional treatment methods.

Four large California metropolitan water systems serving a combined population of over 9,000,000 people presently transport more than 900 mgd over distances in excess of 185 miles (*5*). Two of these systems transport water which receives no treatment other than chlorination and fluoridation, through transmission lines respectively 338 and 388 miles in length. The cost of water delivered to large consumers (more than 1,000,000 cu ft per month) ranges up to $209 per million gallons.

The probable maximum cost of complete water treatment for any of the four metropolitan areas considered, assuming that the flows are divided between two treatment facilities of equal capacity, is estimated at $30 per million gallons, an increase in total cost of about 15 per cent. If filtration and chlorination only were employed on these supplies, the increased cost of

TABLE 2

Comparison of Water Costs

Item	Cost $/mil gal	Reference
Water Treatment (Flocculation, Sedimentation Filtration, Chlorination)		
50-mgd plant		
Capital recovery ($i = 0.05$, $n = 20$)	18	Eq 7
Operation and maintenance	15	
Total cost	33	
5-mgd plant		
Capital recovery ($i = 0.05$, $n = 20$)	43	
Operation and maintenance	35	Eq 7
Total cost	78	
Ground Water Development		
Power, operation and maintenance, and capital recovery (100-ft lift)	15–30	Ref. *4*
Surface Water Importation		
Los Angeles area (from Owens Valley–	131	Ref. *5*
San Francisco-Oakland area)	150–209	Ref. *5*
California Water Plan		
Los Angeles area		
Capital recovery	66	Est.
Operation and maintenance	42	Ref. *8*
Total cost	108	
San Diego Area		
Capital recovery	66	Est.
Operation and mainenance	69	Ref. *8*
Total cost	135	
Sea Water Reclamation		
Distillation		
Vapor compression	400–800	Ref. *9, 10*
Multieffect	480–800	Ref. *9, 10*
Solar	840–1,650	Ref. *9, 11*
Vacuum flash	300	Ref. *9*
Super critical pressures	300–840	Ref. *9*
Electrolytic processes		
Operated on sea water	800	Ref. *9–11*
Operated on brackish water (power only)	260*	Ref. *9, 11*
Freezing processes	1,230	Ref. *10*
Thermodynamic power requirements		
Minimum theoretical†	28	
Practical minimum	120	Ref. *9, 11*
Waste Water Reclamation		
Large plants	30–60	Ref. *7*
Small plants	80–270	Ref. *7*

* Estimated by assuming a reduction in salinity from 4,000 ppm to 300 ppm, a power requirement of 7 kwhr per 1,000-ppm reduction, and a power cost of $0.01 per kilowatt-hour.

† 2.8 kwhr per 1,000 gal sea water at $0.01 per kilowatt-hour.

water would probably be less than 10 per cent.

It is particularly significant to note in connection with the California Water Plan that the cost of water importation to Southern California is likely to exceed, by several times, the cost of water treatment. For example, the probable cost of treatment for water from a 50-mgd plant is about $33 per million gallons, while the expected cost of transporting water to the San Diego area through the California Aqueduct is estimated at $135 per million gallons. The total cost of treated water delivered to a San Diego area distribution system is distributed among the various cost items about as follows:

Item	$/mil gal
California Aqueduct	
Capital recovery	66
Pumping, operation, and maintenance	69
Water treatment	
Capital recovery	18
Operation and maintenance	15
Total cost of treated water	168

If the water were filtered and chlorinated only the cost could be reduced to about $150 per million gallons. Additional costs for chlorination alone would probably be in the order of $1–$2 per million gallons.

Sea water reclamation. The economics of sea water conversion to fresh water is determined primarily by the energy required for the separation. It appears that about four times the theoretical minimum thermodynamic energy (2.8 kwhr per 1,000 gal) will be necessary irrespective of the process employed. Thus, if power is available at 1 cent per kilowatt-hour the cost of energy alone will not be less than about $120 per million gallons.

A number of techniques are available for sea water conversion, but none have yet proved economical for large-scale application. Vapor compression distillation, solar distillation, and multiple-effect evaporation have all been exhaustively studied, but none of these processes appears capable of producing usable fresh water for less than about $300 per million gallons. Electrolytic processes do not as yet appear capable of producing satisfactory water from concentrated sea water for less than $800 per million gallons, but when operated on brackish water (4,000-ppm salinity), the prospects appear hopeful for obtaining potable water for as little as $60 per million gallons. Freezing processes do not appear capable at the present time of producing fresh water for less than $1,200 per million gallons.

It may be concluded that the cost of conventional water treatment in large plants (greater than 50-mgd capacity) will be generally less than 10 per cent of the cost of any available method of sea water conversion.

Waste water reclamation. Reclamation of water from domestic- or industrial-waste effluents by the use of modern water filtration techniques appear to have considerable promise for relieving the strain on overburdened water supplies. Although it has not been proposed that such waters be reused for domestic purposes, many industrial and agricultural uses might be satisfied without danger to public health.

McGauhey (*6*) in reviewing the economic worth of reclaimed water reports numerous instances where water suitable for agricultural or industrial reuse was produced from domestic sewage at costs less than $100 per million gallons. Arnold, Hedger, and Rawn (*7*) in 1949 estimated that the cost of obtaining water from sewage through the medium of a well designed reclamation plant would range from about $30 to

$60 per million gallons for large plants and $80 to $270 per million gallons for small plants. It should be noted that these estimates are somewhat higher, although roughly in accord with the costs for complete water treatment which have been presented herein.

It appears that for certain limited uses, waste water reclamation techniques applied to large plants are capable of producing water at costs less than one-third the cost of water importation to Southern California by such schemes as the California Water Plan.

A summary of costs associated with the development, transportation, treatment, and reclamation of water is presented in Table 2.

Summary

In the preliminary stages of planning for water projects, whether on a local scale or for a state's entire water resources, it is well to be aware of the most probable costs of the numerous alternatives and the range of expenditures which can be expected. Admittedly, the data presented herein do not permit a precise determination of costs, but results obtained using the methods described should not be far outside the tolerances expected in preliminary estimates. Actually, because of a rapidly changing labor and materials market, the design engineer who consistently estimates within 10 per cent of the contract price may consider himself fortunate. Disagreements between contract and estimate on the order of 20 per cent, or more, although very embarrassing, are not uncommon.

It has been the intent of this article to present the picture of water treatment costs as they exist in California, to indicate the trends in cost as a function of plant capacity and rate of increase of water production, and to illustrate the relative importance of expenditures for treatment, water importation, sea water conversion and waste water reclamation. The most salient features of this presentation may be summarized as follows:

1. A cost of construction index for water treatment facilities was developed. The index may be readily synthesized from published cost data and the Marshall and Stevens equipment cost index.

2. Cost of construction was conveniently related to the design capacity of complete water treatment plants by an expression of the form:

$$C_T = K_1 Q_a^p$$

For California plants K_1 and p were noted to be about 257 and 0.67, respectively.

3. Operation and maintenance costs were found to be related to the average treated flow, Q_a, by an expression similar in form to that for construction costs:

$$C_O = K_2 Q_a^q$$

For California plants K_2 and q were found to be approximately 68.4 and -0.41, respectively.

4. The total cost of water treatment was an inverse function of the size of plant and also dependent on the rate of plant growth, the capital recovery period, and the interest rate.

5. The cost of delivering ground water to a municipal system in California's Central Valley is estimated to range between $15 and $30 per million gallons. A surface supply requiring treatment would be competitive only if more than about 60 mgd were required.

6. The cost of treating surface supplies for several large California municipalities is estimated to average less than $30 per million gallons, or about

15 per cent of the present cost of water to large consumers.

7. The total cost of complete water treatment by a 50-mgd plant was less than one-third the estimated cost of water importation to the San Diego area by the California Aqueduct.

8. At the present time the cost of sea water conversion to fresh water is at least ten times as great as the cost of conventional water treatment in large plants (greater than 50-mgd capacity). The minimum cost of power alone for conversion processes is roughly three to four times the cost of water filtration.

9. Water reclamation techniques are capable of producing water for certain agricultural and industrial uses at costs generally less than one-third the cost of importation of surface supplies to southern California by the California Water Plan.

Acknowledgments

The authors wish to express their appreciation to the many individuals and agencies whose cooperation and assistance facilitated the preparation of this paper. Special acknowledgment is due to C. H. Oglesby of Stanford University for his counsel on construction practice.

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Use of Alum-Activated Silica as a Coagulant Aid

Virgil W. Langworthy

A paper presented on April 12, 1957, at the Kansas Section Meeting, Wichita, Kan., by Virgil W. Langworthy, Omega Machine Div., B-I-F Industries, Inc., Providence, R.I.

THE evolution of activated silica preparation from batch to continuous process has been accompanied by an increased use of this coagulant aid. Many plant operators are studying applicability of activated silica to diverse water or waste treatment problems. In the following description of the steps which might be taken in carrying out such a study, the terms used are those defined by Black (*1*).

Operating personnel generally become sufficiently alarmed to investigate activated silica when it becomes evident that treatment plant efficiency is in need of improvement. Such evidence may appear in the form of increased raw-water turbidity, higher color values, floc carryover to the filters (with attendant shortened filter runs), or increased chemical coagulant costs without beneficial results. This last circumstance particularly pertains to treatment of cold, surface supplies. Some operators report that use of activated silica has enabled them to exceed designed treatment capacity during overload periods. It should not be considered, of course, that activated silica or any chemical compensates other than temporarily for needed plant expansion or improvement.

It is recognized that water treatment problems vary with the locality. It is, therefore, not possible to accept wholesale the data accumulated at widely divergent plant sites. Some basic approach, however, is required and the standard jar test remains perhaps the best investigative procedure available. Properly performed, jar tests make a real contribution to successful and economical plant operation.

Literature is available (*2*) which is helpful in preparing the several types of silica sols. Jar test performance procedures are also provided. Study of all available literature is recommended to the operator interested in improving his plant treatment process.

Calculation of Dosage

The basis on which dosages are calculated is the silicon dioxide content of the sodium silicate employed. The composition of a commonly used commercial sodium silicate closely approximates 8.9 per cent sodium oxide, 28.7 per cent silicon dioxide and 62.4 per cent water. A gallon of this product weighs 11.6 lb. Thus, 28.7 per cent of any unit of sodium silicate will represent the silicon dioxide content. Chemicals are normally added on a weight basis to water under treatment; it follows that for 1 ppm silicon dioxide per million gallons, 29.1 lb of the silicate would be required. This corresponds to 2.51 gal (at 11.6 lb/gal) for the same silicon dioxide dose. It re-

mains only to multiply by 29.1 the number of million gallons being treated to determine the total pounds of silicate required for a total dose. The number of gallons may be determined in a similar manner by using the factor 2.51.

It is vitally important in all discussions involving activated silica that terms be understood. Inquiries to equipment manufacturers, for example, should state clearly that dosages desired per million gallons are expressed as silicon dioxide. Considerable confusion will be eliminated if this practice is followed.

Percentage Neutralization

Aging concentration, gel time, and mole ratio are outside the scope of this paper. Adequate coverage of these aspects of silica activation has been given by others (*1, 3–5*). It should be noted that these reports contributed greatly to the development of continuous silica activation equipment. Several studies are particularly worthy of note in their attempts to clarify some common misconceptions.

In the interests of determining the efficacy of aluminum sulfate as an activating agent, laboratory experiments were conducted on synthetically turbid (0.5 g/l clay) water. These preliminary experiments indicated the validity of this type sol and several exploratory runs showed that 5 ppm activated silica was required to form a good floc. It was also concluded that no appreciable improvement in treatment resulted from increasing sol aging time beyond 10 min and no benefit is realized from mixing the sol during aging. It should be noted that these experiments were conducted before field installation of alum-type activated silica equipment.

TABLE 1

Coagulation Test Results When Using Alum-activated Silica *

pH	Dosage—*ppm*		Duration of Test—*min*			Floc	
	Activated Silica	Coagulant Alum	Mix	Stir	Settle	Time to Appear *min*	Result
7.2	2	20	5	10	30	2	Pinpoint
7.2	2	40	5	10	20	2	Fair
7.2	2	60	4	10	15	Immediate	Good
7.2	2	60	5	10	15	Immediate	Good
7.2	2	60	5	10	15	Immediate	Good
7.2	2	60	5	10	15	Immediate	Good
7.2	0	60	3	10	30	2	Fair
7.2	2	60	3	10	30	2	Fair
7.2	4	60	3	10	30	2	Fair
7.2	2	60	2	3	10	1	Good
	0	2	10	20		5	Fair
	0.75	2	10	20		6	Excellent
	1.5	2	10	20		6	Good
	2.0	2	10	20		6	Good
	2.25	2	10	20		6	Fair to Good

* All tests conducted at solution temperature of 25° C, with sol aged 10 min. Results for which no pH is given are for a run at another treatment plant at which existing chlorine-type equipment was converted to alum activation.

TABLE 2

Coagulation Test Results When Using Chlorine-activated Silica *

Dosage—*ppm*			Duration of Test—*min*			Floc		Supernatant
Alkali ($Ca(OH)_2$)	Coagulant		Mix	Stir	Settle	Time to Appear *min*	Result	
	Alum	$-SiO_2-$						
With Sol † Containing 4,500 ppm Total Chlorine								
6	10	0	5	15	5	3	Fair to Good	Clear Suspended Particles
6	10	0.5	5	15	5	3	Fair to Good	Slightly Cloudy
5	9	0.5	5	15	5	3	Fair to Good	Cloudy
4	8	0.5	5	15	5	3	Fair to Good	Cloudy
3	7	0.5	5	15	6	3	Fair to Good	Cloudy
0	7	0.5	5	15	5	3	Fair to Good	Very Poor
With Sol ‡ Containing 5,100 ppm Total Chlorine								
6	10	0	10	15	7	5	Fair to Good	Clear Suspended Particles
6	10	0.5	10	15	7	5	Fair to Good	Cloudy
5	9	0.5	10	15	7	5	Fair to Good	Cloudy
4	8	0.5	10	15	7	5	Fair to Good	Cloudy
3	7	0.5	10	15	7	5	Fair to Good	Cloudy
0	7	0.5	10	15	7	5	Fair to Good	Cloudy

* In all cases, temperature was 33°C, turbidity 120 ppm, and pH 8.2. All sol (1 per cent) was aged 10 min.
† Gel time: 60 min.
‡ Gel time: 45 min.

TABLE 3

Coagulation Test Results When Using Chlorine-Activated Silica With Ferric Sulfate *

Jar	Dosage—*ppm*				Duration of Test—*min*			Floc		Supernatant
	Alkali ($Ca(OH)_2$)	Coagulant			Mix	Stir	Settle	Time to Appear *min*	Result	
		Al	Fe	SiO_2						
1	12	12	4	0	5	15	5	3	Good	Suspended Particles
2	12	12	4	0.5	5	15	3	3	Excellent	Clear
3	8	12	0	0	5	15	—	—	Poor	No Floc
4	8	12	0	0.5	5	15	5	5	Fair	Cloudy
5	8	14	0	0.5	5	15	5	5	Fair	Cloudy
6	10	14	0	0.5	5	15	5	5	Fair	Cloudy

* Data obtained under raw-water conditions, March 1957.

Results recorded in Table 1 were obtained from a field installation of continuous alum-type activating equipment. It should be noted that only 2 ppm activated silica was required (in addition to 60 ppm alum) to produce good treatment results. Again, no demonstrable improvement was noted when the 1.0 per cent sol was aged for periods up to 65 min. Table 1 also illustrates the means by which the optimum dosage of 1 per cent sol aged 10 min was selected for the results recorded. In order to evaluate results of alum-type activated silica on a separate water supply, existing chlorine-type equipment was converted to alum activation at another plant. Results of one run are included in Table 1. A dose of 0.75 ppm activated silica and 34.24 ppm alum were more than adequate to produce good treatment results. Each of these plants has a sludge blanket clarifier. The raw water at each plant was virtually free of turbidity at the time of the experiment.

Experiments were performed at another treatment plant where chlorine serves as the silica-activating agent. A 1.0 per cent aging concentration and 10-min aging period were maintained for the runs recorded in Table 2. In order to demonstrate the effect of gel time, however, the sol used for the results of one of the runs in Table 2 contained 4,500 ppm available chlorine (gel time 60 min) while that of the other contained 5,100 ppm (gel time 45 min). Results from both runs are inconclusive, although evidence is clear that no benefit is derived from shortened gel time. On the contrary, it appears that a 60-min gel time might be the optimum. In order to clarify this point, further runs were made and the 60-min gel time was established. Table 3 illustrates the final plant-scale chemical dosages and fairly well summarizes data obtained under raw-water conditions which existed early in March 1957. It should be noted that 4 ppm ferric sulfate was required to produce an acceptable supernatant. The benefits derived from the use of activated silica are clearly evident when the results in Jar 1 are compared with those in Jar 2.

The observations of other investigators with respect to the direct application of results from one plant to another are wholeheartedly endorsed. It is emphasized, however, that treatment plant operators can obtain substantial improvements in coagulation and other areas of the process. Such improvements result only from careful study and conscientious effort.

Summary

Increasing attention is being given to the use of activated silica as a coagulant for use in solving specific water treatment problems. Although no panacea, activated silica might point the way to improved plant efficiency if the problem is clearly defined and jar test results are properly evaluated. All water works men are encouraged to use specific terminology when referring to dosage. Field studies indicate that aluminum sulfate is a satisfactory activating agent. Results indicate that aging time need not extend beyond 10 min, to be effective. No discernible difference was noted when gel time was varied at 1.0 per cent aging concentration on a reasonably turbid water.

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Solving a Difficult Construction Problem

Byron E. Payne

From a discussion presented on Sep. 24, 1957, at the Kentucky-Tennessee Section Meeting, Louisville, Ky., by Byron E. Payne, Chief Engr. and Supt., Louisville Water Co., Louisville, Ky.

Three years ago the Louisville Water Company engineering staff and a contractor for a Kentucky state highway project were faced with a rather interesting construction project in connection with the reconstruction of an old stone arch bridge supporting a 48-in. cast-iron transmission main.

This 48-in. main, which was carrying about one-third of the water supply for Louisville, could not be taken out of service. It crossed Beargrass Creek on the old bridge, which also carried the Lexington Road (Highway 60). The contractor had the task of demolishing this old bridge and replacing it with a wider, reinforced-concrete box section with a span of approximately 50 ft. The specifications called for the contractor to relay this 48-in. main to the satisfaction of the Louisville Water Company.

It was first planned to construct the north half of the new bridge beyond the stone arch span; purchase 48-in. bends and lugged pipe; cut and relay the main on this new section of the bridge; then remove the old main, demolish the stone arch, and rebuild the new bridge in its place.

This would have involved some very expensive cast-iron fittings, some costly pipe laying, and more loss of service time than could be afforded. Therefore, the following method was developed:

1. Twelve-inch H column bents were constructed at each end of the span astride of the 48-in. main, by driving the H columns to rock and cross-bracing them with welded channels.

2. Two 30-in. plate girders were placed on these bents, one on each side of the 48-in. main, spanning about 60 ft over the creek and the old bridge. U bolts were then threaded under the pipe at 6-ft intervals and fastened with adjusting nuts to 6-in. channels resting on top of the girders.

3. The weight of the pipe was taken on the girders by taking up on these adjusting nuts, and the earth fill was removed from under the pipe. The old bridge was then demolished, the creek channel cleaned, and the new concrete bridge built. Concrete cradles were constructed on the top slab of the bridge under the pipe, the load slacked off on the U bolts, the girders and bents removed, and the new bridge was then carrying the pipeline.

4. The fill was then made over the bridge covering the main, and the new road surface was constructed. This project took several months to accomplish, but water was flowing through this main constantly. The precaution was taken of placing joint clamps on each exposed bell and spigot joint to prevent any joint failures.

This job was accomplished to the company's satisfaction, since the main was continued in service in place. The contractor in turn saved money and was able to reuse the girders in another bridge.

New Method of Preparing Activated Silica Sols

Clarence R. Henry

A contribution to the Journal by Clarence R. Henry, Research Chemist, Miami Dept. of Water & Sewers, S. Miami, Fla.

ACTIVATED silica is used in water treatment to improve coagulation. The floc particles which are formed by its use are larger, heavier, and settle more rapidly. This increases plant capacity, produces longer filter runs and better clarification before filtration, and reduces the nececessity for rigid control of pH.

For many years after the first development by Baylis (*1, 2*) and Graf and Schworm (*3, 4*) activated silica was considered to be a coagulation aid only —one which improved the action of the iron and aluminum salts used to coagulate soft surface waters. By its use, the range of pH which provided optimum coagulation conditions was extended and the character of the floc was improved.

In lime softening, however, activated silica is a true coagulant. Lime alone may give no settleable particles and the results from the addition of iron or aluminum salts may be mediocre or neutralized by the effect of pH. Above a pH of about 10.7, even a small amount of magnesium may produce a large settleable floc. In some waters, the addition of as little as 2 ppm of activated silica as silicon dioxide will produce an excellent floc throughout the pH range in which measurable softening occurs (*5*).

Preparation of Silica Sols

The grade of sodium silicate * used in the preparation of the silica sol contains approximately 28.7 per cent SiO_2 and 8.7 per cent sodium oxide (Na_2O), is of 41° Be or 1.395 sp gr, and weighs 11.6 lb/gal. It is a grey, syrupy liquid —the cheapest form of silica—and it is completely ineffective.

A sol is prepared containing negatively charged colloidal particles formed in the reaction of diluted sodium silicate with an acidic material or other activant. The colloidal particles, or micelles, grow in size to form long branched chains profusely entangled in a brush heap structure, and finally gel into a more or less solid mass (*6*).

Probably the first activated silica sols successfully used were those of Baylis (*1*) in Chicago and Graf and Schworm (*3*) in St. Louis in 1937. Baylis diluted the sodium silicate to about 1.5 per cent SiO_2 and neutralized about 85 per cent of the alkalinity with dilute sulfuric acid. After a 2-hr aging period, the sol was further diluted to 0.6 per cent silicon dioxide, to prevent gelation. An excess of alum was added by Graf and Schworm so that free acidity was present, and a lesser amount, leav-

* The sodium silicate used was N-Brand, a product of the Philadelphia Quartz Company, Philadelphia, Pa.

ing some residual alkalinity, was used by Baker and Dedric (*7*) to form an insoluble metal silicate. The various sols have been reviewed by Merrill (*8*) and by Black (*6*). A descriptive notation for these sols has been given. It consists of the expression "% SiO_2 × *A*%," in which "% SiO_2" gives silica concentration and "*A*%" gives

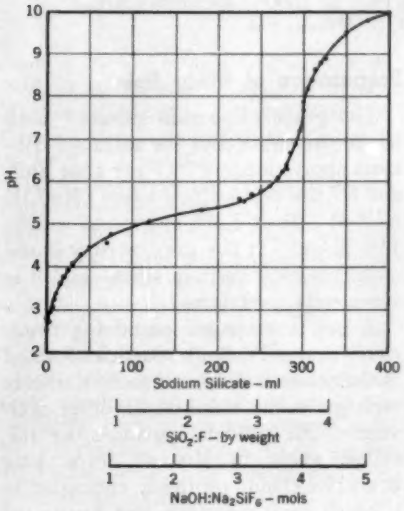

Fig. 1. Titration Curve

One liter of 0.7 per cent solution of Na_2SiF_6 was titrated with a 5 per cent silicon dioxide solution of sodium silicate.

the amount of activant or the degree of neutralization of the alkali by the activant (*5*).

Generally, one may produce a silica sol through the action of an acid such as sulfuric acid, hydrochloric acid, chlorine, or CO_2; an acid-forming substance such as sodium bisulfate, sodium bisulfite, and sodium bicarbonate; or metal salts such as ammonium, aluminum, or iron salts. The attractive activants, of course, are those lowest in toxicity and handling hazard and those most readily available. Most attractive of all would be those which are already in use in the plant and which would remain in a usable form after activating silica. Sulfuric acid, although cheap, constitutes a distinct hazard in handling. The strong acids lower pH markedly and tend to produce rapidly geling sols, while carbon dioxide, sodium bicarbonate and ammonium sulfate are easier to control. Chlorine will activate the silica and still be available for chlorinating the water. Ammonium salts will add ammonia to the water and be useful in maintaining combined chlorine residuals, but will greatly increase the cost of free residual chlorination.

TABLE 1

Characteristics of Sodium Silicofluoride (Na_2SiF_6)

Purity—*per cent*	98.5
Fluoride as F^-—*per cent*	60.0
Solubility at 25°C—*mg/l*	7.6
pH of 0.7 per cent solution	2.8
Silica from hydrolysis:	
Silicon dioxide/Na_2SiF_6	0.319
Silicon dioxide/F_6	0.526

The first use of activated silica in the United States as the only coagulant in lime softening was made at Ft. Lauderdale, Fla., in 1943 (*9*). A batch preparation of CO_2-activated sol, using 3–4 per cent CO_2 from diesel engine exhaust, has been in use since 1953 in Miami, Fla., as the only coagulant. Of the continuous processes, chlorine activation * is probably the most popular at present. Another commercial device † will continuously produce an active sol from most of the activants pre-

* Employing a WT Silactor, product of Wallace & Tiernan, Inc., Belleville, N.J.

† The Silica Activator, Omega Machine Co., Division of BIF, Providence 1, R.I.

viously listed. Continuous production of a silica sol using CO_2 gas has been described by Andrews (*10*).

Sodium Silicofluoride

Sodium silicofluoride (Na_2SiF_6) is a comparatively new chemical. Some of its properties and potential uses were described in 1949 (*11*). Its use in the fluoridation of water supplies was outlined by Faber (*12*) who stated that the first plant scale study of sodium silicofluoride appears to be the one made at the Sheboygan, Wis., plant in October 1949. Its use in the fluoridation of water supplies has grown very rapidly. By the end of 1955, 24.4 million people in the United States received fluoridated water from 663 plants. Of these, 15.8 million, or 65 per cent, received water from 351 plants where Na_2SiF_6 was used as a fluoridating chemical (*13*). For those plants using it, the chemical is on hand and in stock, feeding provisions are already made, and its use in the activation of silica would simply be a further use of the same chemical.

Moreover, since Na_2SiF_6 hydrolyzes to give silicon dioxide (*11*).

$$2H_2O + SiF_6^{--} \rightarrow 4H^+ + 6F^- + SiO_2$$

or

$$Na_2SiF_6 + 4NaOH \rightarrow 6NaF + H_4SiO_4$$

this one chemical should not only fluoridate the water to which it is added, but also contribute an additional amount of silica to the solution being activated. Table 1 outlines some of the characteristics of Na_2SiF_6. Figure 1 shows the results of titrating the saturated solution of Na_2SiF_6 with a 5 per cent silicon dioxide solution of sodium silicate. It follows the curve of the titration of hydrofluosilicic acid with sodium hydroxide. Some geling occurred at pH 6–7.

A 0.7 per cent saturated solution of Na_2SiF_6 was neutralized with sodium hydroxide to the phenolphthalein endpoint. With no sodium silicate added, a small amount of soft gel was found after 2 days. A similar preparation tested for activity after aging for 1 hr appeared to be quite active. The saturated solution of Na_2SiF_6 showed some slight activity after 41 days.

Favorable Aspects

There are several factors favoring the use of Na_2SiF_6 as an activant for sodium silicate: It is an acid substance which can be used to neutralize the alkalinity in sodium silicate; it may be used at the same time to fluoridate the water to which it is added and, moreover, furnishes an additional amount of silica to the solution being activated; it performs not one or two, but three functions; all components of its molecule but the sodium are used, and even it is used in the formation of the salt—more easily handled than the free hydrofluosilicic acid.

Difficulties

The difficulties to be considered are even more obvious and seem to be more serious. The dosages of silica and fluoride are fixed within rather narrow limits by the nature of the water being treated. Neither one may be greatly varied for the purpose of preparing the sol—unless, of course, the preparation is made from only a part of the total amounts applied to the water—without a rather large effect on the silica-fluoride ratio or degree of neutralization. A comparatively small decrease in the fluoride dosage would leave the sodium silicate insufficiently neutralized, as would an increase in the

silica feed. Decreasing the silica feed would do more than make for a lower dosage, for it would decrease the silica concentration in the sol as well. This might become low enough to delay too long the development of activity.

The silica concentration in the prepared sol is limited by the silica-fluoride ratio requirement and by the solubility of Na_2SiF_6 to about 2–2.75 per cent. The practical maximum is lowered still further by the dissolving rate of Na_2SiF_6. Under the conditions outlined in Table 2, a computation to determine maximum silicon dioxide concentration would be made as follows:

$$0.76 \times 0.6^* \times SiO_2/F = 1.8 \text{ per cent (minimum) to } 2.74 \text{ per cent (maximum)}$$

Adding 0.24 per cent from the hydrolysis of Na_2SiF_6 gives 2.06 per cent and 2.98 per cent. Corrected for silicate volume, the final figures would be 1.96 per cent and 2.76 per cent.

*Sixty per cent F^- in Na_2SiF_6, half the maximum fluoride feed.

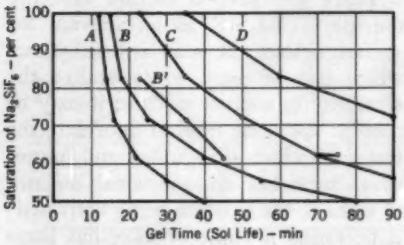

Fig. 2. Relation of Gel Time and Na_2SiF_6 Concentration

Curve A *is for a silicon dioxide-fluoride ratio of 3.5; Curves* B *and* B′ *for a ratio of 3.0;* C, *for a ratio of 2.5; and* D, *2.0. All data were for SiO_2-Na_2SiF_6 sols prepared with distilled water except those used to plot Curve* B′ *and those points shown as open circles where tap water was used.*

Although the gel time or sol life is shown, no means is known for accurately and quickly measuring the activity of silica sols, nor is it clear at what stage maximum activity is developed. Griffin (*14*) recommends that the sol be aged from 2–40 per cent of the sol life in the continuous activation with chlorine gas, where the silicon dioxide concentration is maintained between 1.0 and 2.5 per cent during the 1–2-min aging period.

The work done was based on a feed of 0.7 ppm of fluoride ion to the water

TABLE 2

Factors Limiting Use of Na_2SiF_6 as an Activant of Sodium Silicate

Maximum fluoride feed, possible —*ppm*	1.2
Solubility of Na_2SiF_6*—*per cent*	0.76
Average silica feed†—*ppm*	2–3
Silicon dioxide–fluoride ratio—	
with 1.0 ppm F	2–3:1
with 0.5 ppm F	4–6:1

* At 25° C.
† As silicon dioxide.

and a working solubility for the Na_2SiF_6 of 0.7 per cent. Figure 2 shows the gel time for several sol preparations which were made up for different silicon dioxide–fluoride ratios at varying concentrations. The line for the 3.0:1 ratio would represent a feed of 0.7 ppm of fluoride ion and 2.1 ppm of added silicon dioxide throughout its length. The Na_2SiF_6 would furnish 0.42 per cent fluoride ion and 0.22 per cent silicon dioxide and the sodium silicate, 1.26 per cent, to give a total of 1.48 per cent SiO_2 in the Na_2SiF_6-saturated solution. This high a concentration would be possible only in batch operation, which is just where a rapidly geling sol is not wanted. Greater dilution in larger tanks would be necessary to prepare stable sols.

The process is quite feasible for batch operation.

Figure 3 rearranges the data of Fig. 2 to show the relationship between gel time and silica concentration. The degree of neutralization as fixed within the silica-fluoride ratios of 1:1 and 3.5:1 has no effect on this relationship. The pH measurements were between 5.3 and 7.3. This is higher than shown on the titration curve, probably because of the effect of the high fluoride concentration on the glass electrode. The sols of the 4:1 ratio had a pH of 8.8 and a much longer gel time.

The life of a sol prepared with Na_2SiF_6 appears to be much shorter than that of sols prepared with other activants. The 0.26 per cent silicon dioxide sol gels in 1.5 hr. This is the concentration Baylis used to prevent gelation during storage of the sol.

In continuous activation within a tank used for dissolving $NaSiF_6$, partial gelation is more than likely to develop where short-lived sols are produced. Continuous adjustment would be necessary to produce sols having minimum life for immediate activity development which would also be safe from gelation and clogging of equipment.

Although higher silica concentrations will develop activity most rapidly, they should be avoided both for batch and continuous operation. For continuous production, aging time should be held to a minimum also, because of the danger of gelation and partial gelation, coating and clogging, and because of the added control measures necessary. The problem consists in finding if a workable continuous process can be developed within this framework.

Results of Experiment

The laboratory work done to explore the feasibility of preparing these sols by continuous process is summarized in Table 3. From this, it appears that active sols may be prepared within the silica-fluoride ratio range of 2.5:1–3.5:1 and that the sol preparation may vary in pH from 6 to 7 and in silicon dioxide from 0.6 to 1.3 per cent. It was believed that the ranges might be broader in practice. Activity appears as a lowered turbidity after 10 min settling. Outside of the range for short-time aging of the sol, activity does develop, but more slowly. The shorter the gel time or sol life, the more rapidly is activity developed.

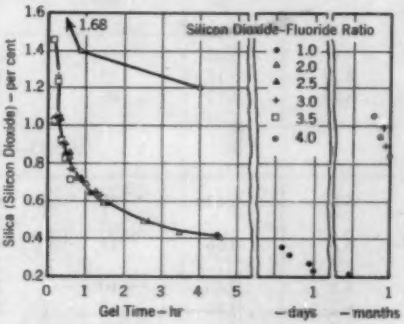

Fig. 3. Relation of Gel Time and Silica Concentration

Curves are derived from same data used for Fig. 2.

The active sols developed pH in the range of 6–7. Although not a good control measure, the determination of pH should serve to indicate whether or not the operation is proceeding properly.

Plant Scale Application

Full-scale plant application as a continuous process was begun on Nov. 8, 1956, at the Hialeah, Fla., water treatment plant. This was carried on 4–7 hr per day. Undiluted sodium silicate was added directly to the Na_2SiF_6 dissolving tank where it was held 20–30

min before dilution by the eductor. The sol was carried by some 115 ft of 3-in. pipe to a 55-gal drum which served to proportion the flow through two outlets to the mixing tanks. It was fed immediately after the lime, which, in turn, was preceded by return sludge from the water plant—a conventional lime softening plant which uses free residual chlorination to reduce color. Treatment rates vary within the 50–75 mgd range. In normal operation no coagulant is added with the excess lime treatment to pH 10.8. Na_2SiF_6, used for over 4 years to fluoridate the water, is controlled automatically.

The lime feed was reduced to a level at which a pH of about 10 could be maintained in the flocculators while silica was being fed. No other coagulant was applied. The existing equipment for feeding $NaSiF_6$ was used without any change. A storage tank and a proportioning pump for handling the sodium silicate were added. A flow diagram of the process so applied is shown in Fig. 4.

TABLE 3

*Data on Estimation of Activity**

pH	SiO_2 %	Time Aged *min*	SiO_2 *ppm*	Turbidity After 10-min Settling *ppm*	Gel Time *hr*	SiO_2: F
Saturated Na_2SiF_6 Neutralized With Sodium Hydroxide						
—	0.22	41†	2	71.0		
8.3†	0.17	10	1	48.0, 44.0		
8.3†	0.17	60	1	9.2		
$SiO_2 \cdot Na_2SiF_6$ Sol						
5.6	0.42	10	1.0	200+	4‡	2.0
			3.0	200+		
6.0	0.66	15	1.75	10	90	2.5
			2.0	9		
6.1	0.63	10	2.0	3	70	3.0
6.2	0.79	15	2.0	7	50	
6.6	1.26	10	2.0	3	16	
7.0	0.92	15	2.0	8	23	3.5
		15	2.5	7		
8.6	0.73	10	3.0	180	15+‡	4.0
			5.0	150		
	0.73	3‡	1.0	80		
		3‡	3.0	70		
9.9	1.48	10	1.0	180	—	5.0
		10	3.0	200		
9.9	1.48	4‡	1.0	56	—	
9.9	1.48	7‡	1.0	26	—	

* At lime softening pH of 10.
† NaOH added.
‡ Days.

During 5 days of application it was found that an active sol was produced at a lower silica concentration than anticipated, but control was tedious. Further, a soft, slimy encrustation accumulated on the walls of the dissolving tank in a few hours. A decrease of only 1–2 gpm of dissolving water would bring on incipient gelation at once and an increase did not help to prevent encrustation.

Because of the difficulties in controlling conditions within the dissolving tank, this point of application was abandoned and, on January 11, 1957, the feed of undiluted sodium silicate was made directly into the discharge line from the dissolving tank, approximately 12 in. in front of the eductor. Ample dissolving water was added to hold the Na_2SiF_6 at about 70–80 per cent of saturation and the eductor water was held to a minimum. All activation took place in the 3-in. carrying pipe of 13.4 gal capacity and the 40-gal proportioning tank—total volume 54 gal. This was continued on a 4–7-hr per day basis for 7 days.

The process was put into full 24-hr per day operation on Jan. 24, 1957, and continued for 50 days under the control of the plant operating personnel. Periodic checks, adjustments, and tests were made by the laboratory. Ap-

TABLE 4

Results of Plant Scale Application

Date	Water Treated *mgd*	F^- *ppm*	SiO_2 *ppm*	SiO_2:F	pH	Turbidity* *ppm*	
January							
29	67.2	0.61	2.0	3.3	6.4	14	20
31	65.8	0.69	2.1	3.0	5.8	16	22
February							
					5.7	15	26
1	62.8	0.68	2.1	3.1	5.8	50	50
					6.2	50	22
4	58.4	0.65	2.1	3.1	6.0	18	20
					6.1	10	8
5	61.5	0.69	2.0	3.0	5.8	38	56
					6.0	21	21
6	66.4	0.68	2.0	3.0	6.1	26	8
					6.0	23	23
8	56.8	0.60	2.0	3.3	6.8	30	35
11	59.2	0.62	2.0	3.2	8.5	28	24
					8.5	18	18
12	63.1	0.58	2.0	3.4	6.1	40	16
					6.1	23	30
13	63.5	0.60	2.0	3.3	6.0	22	39
					6.0	36	37
14	60.5	0.57	2.0	3.5	6.5	26	18
					6.1	21	23
15	60.8	0.58	2.0	3.4	5.8	28	27
					5.9	26	27
18	62.9	0.54	2.0	3.7	5.8	45	70

* After 10-min settling. Results are shown for two effluents.

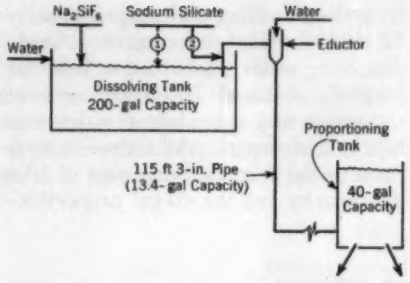

Fig. 4. Flow Diagram, Preparation of Na_2SiF_6

Arrangement is for a 60–70-mgd treatment rate.

proximately 0.6–0.7 ppm of fluoride was fed with about 2 ppm of silicon dioxide. The ratio was between 3:1 and 3.7:1 and produced an apparent pH of 5.8–8.5 in the sol as applied. The silicon dioxide concentration varied between 0.3 and 0.5 per cent. The aging period was about 2 min. Some results of the plant scale run are shown in Table 4.

Several intentional changes were made in order to explore the effect of silica concentration in the sol preparation and of higher silica feed to increase the silica-fluoride ratio. The sludge feed was also changed. The results given in Table 5 show that the silica concentration in the sol preparation may vary between 0.3 and 0.5 per cent or higher. With 0.7 ppm of fluoride, silica feed may go as high as 2.8 (Table 6), giving a ratio of 4.0:1 and a pH of 9. The effect of putting all of the low, variable sludge feed into one flocculator can be seen in this table. More silica was fed into one flocculator than the other. The changing of the total sludge feed produced so little effect that the higher silica requirement seems to indicate that much more water was being treated in the No. 1 flocculator.

Tests and Observations

Visual observation is a very poor means for judging the effectiveness of coagulation. Particularly where return sludge is added during the softening process, the appearance of the flocculated water can be very misleading. Not only does the added sludge increase the amount of silicon dioxide required, but the added bulk of fine material confuses the eye. Laboratory work has shown that the raw water would require about 0.5 ppm of silicon dioxide to produce a floc in lime softening, while the addition of about 830 ppm of calcium carbonate sludge raised that requirement to about 2.0 ppm. The feed of sludge in the plant was usually much lower than the preliminary estimate and the amount added also varied widely and rapidly. When all of the sludge was added to one of the two mixing tanks before the lime, flocculation in the sludge-bearing water often seemed to be very much better than in the water receiving no sludge. Tests of both waters would show that this was not so. The reverse observation was also made.

The test used to determine coagulant effect was based on the amount of fine calcium carbonate particles, measured as turbidity, remaining after a 10-min settling period. Samples were dipped

TABLE 5

*Effects of Varying Concentration of Silicon Dioxide in Sol**

SiO_2 %	Turbidity of Flocculator Effluent—*ppm*	
	Flocculator 1	Flocculator 2
None	90–150	80–125
0.3 Minimum	23–45	30–70
0.4 Normal	15–50	16–55
0.5 Maximum	10–30	8–35

* In plant scale operation.

out of the flocculator effluent in 2-liter beakers and left undisturbed for 10 min. Portions were then taken from a point 1 in. above the bottom of the beaker through a 100-ml pipet whose tip was bent up to avoid disturbing the settled material. The test portion was flowed directly into a 100-ml short-form Nessler tube and the turbidity determined on a photoelectric colorimeter,* using a red filter.† Previous tests and the present ones indicate that excellent flocculation is obtained when the values lie between 10 and 20 turbidity (as silicon dioxide), with values under 40 indicating good results.

TABLE 6

Effects of Changes in Silica-Fluoride Ratio and Sludge Feed

SiO_2 %	SiO_2:F	Ratio of SiO_2 Feed to SiO_2:F	Turbidity *ppm*	
			Flocculator 1	Flocculator 2
0.34	2.9	1.8	8– 12*	10–13*
0.34	2.9	1.8	20– 45*	5–11
0.32	2.5	1.8	10– 25*	4–10
0.56	2.5	2.0	7– 15*	4– 6
None	—	—	60–100*	40–60
0.34	2.9	2.4	25– 35*	12–14
0.20	2.9	1.4	60– 80*	15–25
0.42†	4.0	1.4	6– 11*	3– 8

* All sludge added.
† pH 8.9.

Fluoride Loss

The raw water contains about 0.2 ppm fluoride and 230 ppm of alkalinity. Magnesium and noncarbonate hardness are low at about 8 ppm and 25 ppm, respectively. Experimental work indicates the loss in apparent fluoride content to be about 0.07 ppm. This may result from an analytical deficiency because the addition, after softening of Na_2SiF_6—both as $SiO_2 \cdot Na_2SiF_6$ sol in softening and as Na_2SiF_6 alone—gives the same result.

The difference between the fluoride added and the amount found will give an apparent level for the original fluoride content. Comparison of average values for the preceding 5 months with 20 days of plant operation with the $SiO_2 \cdot Na_2SiF_6$ indicates that no fluoride loss is caused by the change. Na_2SiF_6 may be used to prepare an active sol with sodium silicate for use as a coagulant in the softening of water to pH 10 without loss of fluoride.

Further Observations

Filter runs were not measurably affected in the water plant. Although the filters are not run to exhaustion and improvement was therefore not established, no decrease could be found. The silica as prepared and applied showed no plugging tendency.

The silica feed control is not too critical. The range permissible is much wider than economy itself would dictate. Dissolving and carrying water

* Colorimeter used was a Lumetron 450, product of the Photovolt Corp., New York, N.Y.

† B-630 model, same manufacturer as above.

also may be varied. Greatest effect on the activity of the sol produced will come from variations in the Na_2SiF_6 feed.

No upsets or failures were found during the period that the plant operators were in control, indicating that their normal attention was sufficient. If the silica-fluoride control is lost, no gelation or clogging will result, but simply a loss of coagulant effect. Failure of water feed would cause immediate gelation, but the water feed may easily be connected with the chemical feed to prevent this.

Some material encrusts the feed and carrying lines. It is not very hard but is strong enough to adhere and will gradually decrease the carrying capacity of the pipe. Little difficulty was found from this source in more than 40 days of full-scale operation.

TABLE 7

*Average Data From Full-Scale Plant Run**

Fluoride feed	0.6–0.7 ppm
Silica feed	2.0 ppm
SiO_2:F	2.5–4.0:1
pH	5.8–8.9
SiO_2 concentration	0.3% and higher
Aging	1.9–2.6 min

* Cost of treating 1 mil gal with 1 ppm Na_2SiF_6 at 1 cent per pound is \$0.139; for silicate on same basis, \$0.291. The cost of the Na_2SiF_6 is canceled by its use in fluoridation, and \$0.052 (the cost of the silicon dioxide obtained from the Na_2SiF_6 at a 3:1 ratio) is subtracted from the silicate cost, leaving a net chemical cost of \$0.239.

Average data from the full-scale plant run are shown in Table 7, with the costs of chemicals required restated in one-unit terms. For example, \$0.239 is the cost of treating 1 mil gal of water with 1 ppm of chemical at 1 cent per pound. Two ppm and 3 cents per pound would increase this 6 times to give \$1.434 per million gallons. The cost for 60 mil gal would be \$86.04.

Summary

A $SiO_2 \cdot Na_2SiF_6$ sol may be prepared for use as a coagulant or coagulant aid within the limits imposed by water treatment requirements. The optimum ratio for silica to fluoride is between 2.5:1 and 4:1. For a fluoride feed of 1 ppm, the silica dosage may vary between 2.5 and 4.0 ppm. Hydrofluosilicic acid may also be used to produce activated silica from sodium silicate. The optimum range for the ratio will lie between 4.3:1 and 5.8:1. The prepared sols should contain 0.3 per cent silicon dioxide or more and have a pH between 5.8 and 9.0. Feeding more or less silica results in loss of activity as these limits are exceeded.

The use of Na_2SiF_6 and hydrofluosilicic acid is attractive in that these chemicals not only activate sodium silicate but, in addition, fluoridate the water and contribute active coagulating silica from their own hydrolysis. The chemicals perform three functions. There is no loss in fluoride in the softening of water to pH 10.3 and below.

Activation is very rapid. Plant scale application indicates that this is accomplished in 2 min where the silica concentration is held above 0.3 per cent.

The sols are easy to prepare and control is simple. Little equipment is necessary to add silica activation to existing facilities for feeding fluoride. The equipment needed consists of storage tanks, a proportioning pump, and a water feed rate control device. Two minutes aging time is required for the prepared sol after the addition of undiluted sodium silicate. This may take place in the feed lines and a proportioning tank. The process is suitable for both batch and continuous operation.

An encrustation accumulates on the sol container and feed line and provision should be made for cleaning it—just as in the case of lime feed.

The chemical cost is low. It is less than the cost of the equivalent amount of sodium silicate being activated because of the contribution of silica from the hydrolysis of the silicofluoride compound. This is estimated to be $0.239 per part per million of silica applied at 1 cent per pound for sodium silicate.

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Acceptance of Membrane Filter Procedure

A Report of AWWA Action

APPLICATION of the membrane filter procedure in the laboratory examination of water for coliform bacteria has been steadily increasing. With regard to the acceptability of this procedure as an alternative to the standard MPN procedure, the following resolution was adopted on Nov. 7, 1957, by the Executive Committee of the AWWA Board of Directors:

Whereas the current (tenth) edition (1955) of *Standard Methods for the Examination of Water, Sewage, and Industrial Wastes* includes the membrane filter procedure as a *tentative* method for the determination of the presence of members of the coliform group, and

Whereas the US Public Health Service has, by official action, taken on Mar. 1, 1957, accepted the membrane filter as an alternate to the completed test for members of the coliform group,

Therefore, be it resolved that the American Water Works Association accepts the membrane filter procedure as an alternate to the completed test when the following conditions have been met:

a. The administrator of the laboratory concerned has satisfied himself by comparison tests that the membrane filter procedure produces results which are essentially equal to the completed test, and

b. The state sanitary engineering laboratory approves the application of the membrane filter procedure to the public water supplies under its jurisdiction.

The text of this resolution was published in the December 1957 JOURNAL (page 1530). Quoted below are several communications from AWWA Secretary Harry E. Jordan setting forth the background of this action and certain limitations of the membrane filter procedure.

On Oct. 11, 1957, the Secretary wrote to the Officers of the AWWA Water Purification Division as follows:

The tenth edition of *Standard Methods for the Examination of Water, Sewage, and Industrial Wastes;* contains (*1*) a tentative method of test for the presence of the coliform group—membrane filter procedure. Experimental application of this procedure for laboratory control of water supply quality has increased rapidly.

Acceptance of this valuable tool for water examination has been somewhat delayed by the routine related to the production of the text of *Standard Methods.* The next edition of that text is not anticipated until 1960. While there has been consideration given to a revision of the status of this membrane filter procedure before 1960, the matter is substantially unsettled.

I am now proposing that the Officers of the Water Purification Division review the application of the procedure among their associates and recommend to the Executive Committee that AWWA accept the membrane filter procedure (under certain limitations hereinafter described) as alternate to the MPN procedure which has been standard for a number of years. The precedent for this action exists in the previous action of the Board taken in January 1946, when the Directors of AWWA (actually, before promulgation by the Surgeon General) accepted the USPHS Drinking Water Standards vol-

untarily for application to water supplies under the control of the members of AWWA. This official action was recorded in the March 1946 issue of the JOURNAL (page 361).

Very important action on the membrane filter procedure was taken by the Public Health Service on Mar. 1, 1957, when it promulgated a statement authorizing the use of this procedure as an alternate to the traditional completed test for coliform organisms in the evaluation of water quality for use on interstate carriers. The order permitting the use of the membrane filter procedure makes no distinction between the completed test (MPN procedure) and the membrane filter procedure as a tool for checking water quality.

It has been noted by various workers that the applicability of the membrane filter procedure is limited by [1] the presence of large numbers of noncoliform organisms in the water sample, [2] the presence of dense algae concentrations, or [3] the presence of large amounts of suspended matter. It has also been noted that these limitations actually apply to waters which would not be submitted for certification for use on interstate carriers and, in general, would not be considered acceptable public water supplies.

On the other hand, when dealing with waters which are normally distributed for public use and which are normally free from suspended matter, algae, or large numbers of bacteria, the membrane filter is applicable and gives very prompt indications of the presence of organisms of the coliform type with a minimum of detailed laboratory work.

Agreement should be reached within the states concerning the applicability for use in the membrane filter procedure of culture media which are not included in the description of the procedure in the 1955 edition of *Standard Methods*. Papers have been written and published on modifications of the media described on page 400 of *Standard Methods* indicating that revised composition of the media is preferable. However, the official use of revised formulations should be approved by the director of the state laboratory concerned.

The above memorandum and resolution were unanimously approved by the Officers of the Water Purification Division. Subsequently, on Oct. 24, 1957, the following memorandum was addressed to the Executive Committee of the AWWA Board of Directors:

Your attention is invited to the memorandum addressed to the Officers of the Water Purification Division under date of Oct. 11 concerning the subject of the membrane filter procedure for laboratory examination of water. Each officer has replied and each has approved the memorandum.

It is now transmitted to the Executive Committee with the recommendation that the procedure outlined be approved.

Having the approval of the Executive Committee, the action will be brought to the attention of the members of the Standard Methods Joint Editorial Board (Michael J. Taras, for AWWA; F. Wellington Gilcreas, for APHA; and Gail P. Edwards, for FSIWA) and will be published in the first available issue of the JOURNAL.

The Executive Committee approved unanimously on Nov. 7, 1957. Official notice of the action was sent to the executive officers of APHA and FSIWA on Nov. 12, 1957, as follows:

This is official advice that the Executive Committee of AWWA has approved the unanimous recommendation of the Officers of the Water Purification Division that members of AWWA in responsible charge of laboratories having to do with the production of water for public use consider themselves at liberty to use the membrane filter procedure, provided that the laboratory administrator has satisfied himself by comparison tests that the membrane filter procedure produces

results which are essentially equal to the completed test, and that the state sanitary engineering laboratory approves the application of the membrane filter procedure to public water supplies under its jurisdiction.

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Trends in Air-Conditioning Use and Regulation

Committee Report

A report of Committee 4130 M—Water Use in Air Conditioning and Other Refrigeration, Elwood L. Bean, Chairman. Other members of the committee are L. L. Lewis, Harris F. Seidel, and Marsden C. Smith.

Part 1—Growth Aspects

THE air-conditioning and refrigeration industry is now very much aware of the public water supply field's problems and it is the opinion of the committee that the industry is doing all reasonably possible to meet the challenge of the need for water usage curtailment. Great advances have been made, including changes in attitude and approach within the years spanned by the work of the committee.

Trade journals of the manufacturers now contain numerous articles on the use of water, the need for conservation, means of controlling water flow and use, and the fact that it is the responsibility of the manufacturers to provide the means of conservation. Conservation ideas are widely publicized, service engineers are trained to field-adjust units to conserve water, and customers are indoctrinated with conservation principles.

Many manufacturers have developed practical air-cooled units in sizes to 7½ tons, several to 10 tons, and one has recently placed on the market evaporative condensers of an improved compact design, capable of serving 5–250-ton units, and air-cooled condensers for 2–38-ton units. These are of low silhouette design, suitable for installation either indoors or out. Such developments are new tools for conservation.

Many regulatory bodies have been made aware of the plight of the public water supply industry. Six regulatory commissions (Arkansas, Illinois, Missouri, Nebraska, Wisconsin and Ontario) have approved surcharges to overcome the hardship of the very poor load factor; one (Delaware) has approved requirements for conservation. The committee has not been informed of a single case where a surcharge has been refused by a regulatory commission.

Great numbers of public water supply officials are aware of the problem caused by the increases in air-conditioning installations. When there is a realization that failure to conserve is resulting in, or will result in too heavy mortgaging of the future of a very valuable asset of the community—an adequate water supply—information on what has been or is being done by others is sought. Data of sufficient detail and in compact form, which have not been available, will be presented later in this report.

Air-Conditioning Growth Trends

Substantial gains in air conditioning, with predictions of consistent future growth, have been reported (*1*) as the

result of a survey * in which responses were obtained from more than 50 power companies and water utilities across the United States. Every participating company reported marked increases in the installation of air conditioning in its area. The degree of increase was more pronounced in the South, but the difference from other regions was not great, indicating that outside temperature alone is not responsible for the growth of air conditioning. Central air-conditioning systems are becoming increasingly popular for residential application and commercial and industrial air conditioning are becoming a competitive necessity in many parts of the country. Power and water companies expect an upsurge in the use of air conditioning and many are making plans now to meet an increasing demand on their facilities.

One highlight in the report was the trend toward air conditioning in areas not normally regarded as outstanding markets because of their mild climates. For example, air-conditioning installations in northern and central California showed a sharp increase for 1956 over 1955. Until recently, it was generally assumed that the San Francisco Bay area needed no air conditioning because of the relatively low summer temperatures. Three of the newest 8–12-story buildings in downtown San Francisco, however, are completely air conditioned. The Seattle area seldom experiences high summer temperatures, yet many installations are reported there, because the internal heat load of the buildings makes air conditioning mandatory.

The trend toward air conditioning of factories is rapid, especially in the South, where it has been estimated that as many as 75 per cent of new factories—and 50 per cent of all factories —will be air conditioned by 1960. The trend is spreading to the North also—particularly in factories involving high skills, like work in electronics. Factors in the trend include competition for skilled help, the desire to maintain employee efficiency, and the fact that there is a sound financial return from reduction of absenteeism, improvement in production efficiency, and, frequently, an improvement of product quality. It is interesting to note that a modern computer or "mechanical brain" requires 100 tons of installed cooling, half of which operates continuously.

With regard to types used for residential air conditioning, 185,000 central units were installed in US homes in 1956. New central units are being developed which require limited duct work for installation in existing homes. These developments are tending to increase such sales. It is now acknowledged that the problems which air-cooled condensers in the medium sizes have brought are not as bad as was anticipated, and air-cooled equipment is being marketed in larger sizes each year.

Heat Pumps

Heat pumps, purportedly for year-round service (air conditioning *and* heating) are now available in sizes from 10 to 125 hp. It is estimated that 7,000 installations were made in homes in 1956. The market for these devices is still limited, but the public is beginning to buy more of them, and, as they are developed and give better service, under year-round conditions, sales will no doubt multiply.

* By the Trane Co., La Crosse, Wis.

Leasing of Equipment

One corporation with headquarters in Philadelphia has been leasing air-conditioning equipment for 3 years. Branches have been established in several cities and by the end of 1957, it is reported, 100 cities may have branch offices. Leases are signed for 2–5 years, on a fixed monthly-charge basis. They vary with the installation but may include all wiring or required building modifications as well as complete maintenance of the conditioning equipment. The company specializes in leasing to hotels, motels, and office buildings. Either water- or air-cooled equipment will be furnished.

Licensing of Contractors

Five cities are known to have enacted ordinances requiring that those who install air conditioning or refrigeration shall be licensed. At Shreveport, La., three classes of certificates are established for "air conditioning, heating, mechanical refrigeration, and ventilation contractor." Class *A* is for installations which do not "exceed 7½ hp or the equivalent tons in refrigeration"; Class *B* extends to 25 hp or equivalent tons; and Class *C* is unlimited. Annual Fees are $50, $100, and $150 respectively. Kansas City, Mo., requires that refrigeration systems be installed by "a master pipefitter or by a licensed refrigeration contractor." Bismarck, N.D., provides that a "License . . . shall be issued . . . to any master plumber, master electrician, or heating contractor who proves his competency." A $10 fee and $1,000 bond are required. South St. Paul, Minn., exacts a $25 fee. At Detroit, there are three classes of licenses of which there are now over 400 holders.

Installed Air Conditioning

Total air conditioning—excluding window types—installed in some major cities was reported at the end of 1955 as:

City	Air Conditioning *tons‡*
New York City*	275,218
Baltimore	137,304†
Pittsburgh	87,500
Dallas	169,452
Houston	26,902
Chicago	255,000

† Manhattan only.
‡ Horsepower.

Density of nonconserved air-conditioning installations in 1956 in the following cities has been stated (*2*) in terms of tons per 1,000 population to be:

Omaha	71	Detroit	44
Chicago	60	Kansas City, Mo.	17
		Milwaukee	60

Sales reports indicate that total installations of air conditioning in 1956 were about a third more than those in 1955; in Detroit and Nashville, more than 60 per cent more than those in 1955.

Water Use

In Chicago's downtown area of 0.94 sq mi, the air-conditioning tonnage is believed to be 81,000, with only 15,000 tons conserved. Peak consumption on Jul. 29, 1955, was 99.4 mgd, whereas the normal, as measured on Dec. 14, was only 35.4 mgd—a ratio of 2.8 to 1. Because the peak estimate would equal only 9 hours operation of the nonconserved units (at 1.75 gpm per ton), it is not unreasonable. In this area, the ultimate air-conditioning load is predicted to be 200,000 tons.

In Milwaukee, the report of the water system expansion consultants in 1957 stated that air conditioning used water at a rate of 50 mgd and that if no controls were established, this would soon be doubled.

A limiting ordinance was adopted in Grand Rapids, Mich., following a study which indicated that nonconserved water-cooled air-conditioning systems used up to 22 per cent of the total consumption on maximum days and absorbed 4 per cent of total yearly consumption.

Trenton, Mo., found "by metering, before and after cooling equipment was installed, that the monthly averages were . . . 3,500 cu ft for 3-ton units, 4,600 cu ft for 5-ton units, and 6,300 cu ft for 10-ton units."

At Athens, Tenn., with 10 tons of nonconserved air conditioning, per 1,000 population, the waste of water was estimated in 1954, 1955, and 1956, to be 10 , 11, and 10 per cent, respectively, of the total consumption during the peak month. Assuming 12 hr per day average operation, which might be true in those peak months, this would give 1.75 gpm per ton on all equipment and would indicate that 100 tons of nonconserved air conditioning per 1,000 population would double the water use.

Litigation

Three court cases have been reported regarding the control of water use for air conditioning: at Oskaloosa, Iowa; Moorhead, Minn.; and Detroit. The first was withdrawn before actual presentation of the case. In the second, an injunction was granted against the water utilities, but later withdrawn at the request of the complainants. The third is a challenge to the use of "surcharges" or "demand charges," and no ruling has yet been made by the court.

Part 2—Survey of Regulations and Charges

In April 1957 questionnaires were distributed by the Association to all members in the United States, Canada, Hawaii, and Cuba. Nearly 700 replies were received by the committee, with many also reporting on other communities. Special letters were sent to the officials in all such reported communities, and only information that was confirmed has been included in the survey tabulations. As far as possible, copies of the actual regulations, ordinances, or orders were obtained and information abstracted by the committee. This was the method used for compiling data for more than 80 per cent of the communities.

A total of 466 reported no regulations or special charges; 40 reported that regulations or special charges are officially being considered; and 203 presently have ordinances, regulations, or orders in effect.

The ordinances received vary from very complete documents (many following closely the "model code" prepared by this committee and published in the JOURNAL (*3*)) to others which are very simple. The record for the shortest regulation no doubt is held by Woodstock, Ont., where the public utilities commission regulations contain just one sentence of ten words: "No water is to be used for air-cooling purposes."

Analysis of the data from the 203 ordinances, regulations, or orders received shows that: one prohibits water

use for air-cooling; one prohibits water use in new installations; 48 require conservation devices on all new installations; and 111 require conservation over certain sizes on new installations. A total of 169 have some form of regulation. Of these, 25 also have established "surcharges," "demand charges," or "special charges," applicable to any nonconserved use by existing unconverted units or by new installations in the sizes allowed to so operate. In addition to the above, 34 have established special charges generally applicable to nonconserved use. A total of 59, therefore, have special charges—more than 28 per cent of those which have any form of regulation.

All data were tabulated according to population group as follows:

Group	Population	Number of Communities Reporting
A	Under 25,000	102
B	25,000 to 50,000	42
C	50,000 to 100,000	22
D	Over 100,000	37
Total		203

Study of the data in these various population groups, however, has failed to establish any significant trends related to different community sizes.

Table 1 shows that 128 or nearly ⅔ of all the mandates were established by city ordinance—as might be expected in view of the preponderance of municipal ownership. Forty-nine derived from regulations promulgated by water utilities, local or district commissions or boards. Twenty were orders of state or provincial service commissions and six did not properly identify the means of establishment.

Permits

Table 2 indicates that 119 communities require permits to install systems; four require annual permits to operate; and 23 specifically require a single permit to operate. In a few instances, permits to operate are required for installations existing at time of origin of the regulation, though quite commonly such owners are required, in lieu of a permit, to notify the water works utility of such existing installations within a specified time. Failure to do so is a violation of the ordinance. Some require that permits to operate be obtained after alterations or major replacements. A great many, after inspection of installation, issue an approval of the installation which serves as a permit to operate. Manhattan,

TABLE 1

Number of Communities Using Various Methods of Establishing Regulation

Method	Number of Communities	Per Cent of Total	Population Group			
			A	*B*	*C*	*D*
Ordinances	128	63.1	64	25	17	22
Regulations	49	24.0	28	9	2	10
Utility commission orders	20	9.9	8	6	2	4
Not stated	6	3.0	2	2	1	1
Total	203	100.0	102	42	22	37

TABLE 2

Communities Requiring Permits for Operation or Installation

Kind	Number of Communities	Per Cent of Total	Population Group			
			A	*B*	*C*	*D*
Installation Permits						
All	111	93.3	52	25	10	24
Some sizes	8	6.7	1	1	2	4
Total	119	100.0	53	26	12	28
Operation Permits						
Annual (renewal necessary)	4	14.8	—	3	—	1
Single application*	23	85.2	10	7	3	3
Total	27	100.0	10	10	3	4

* Many others require permit to install. Approval of installation after inspection serves as permit to operate.

Kan., requires a permit to install only if water is to be used from any source other than the public supply. Connection of new installations to the sanitary sewers is also prohibited.

Fifty-nine communities are known to exact fees for the permits to install. Twenty-eight of these are flat fees of $1–$10 per installation; three are $1 or $2 per ton; seven are $2–$5 plus 10–50 cents per ton; fourteen are forms of sliding scales with $1–$5 minimums and maximums as high as $22; seven are varied individual scales, with some based on the cost of the installation. Highland Park, Mich., specifies an annual inspection of each installation "by the city engineer," with fees imposed ranging from $1 to $25, dependent on the size. It is likely that many of the others that require permits also exact fees; these may be imposed by general codes or regulations requiring fees for all permits.

Table 3 indicates that slightly over half of the regulations cover both air conditioning and other types of refrigeration. Although less than half ap-

TABLE 3

*Form of Installation Regulated—Number of Communities**

Form	Number of Communities	Per Cent of Total	Population Group			
			A	*B*	*C*	*D*
Air conditioning	76	44.7	38	15	9	14
All refrigeration	94	55.3	38	23	10	23
Totals	170	100.0	76	38	19	37

* Data for communities on which information received is clear.

pear to be confined to air conditioning, information is not clear on 33 additional regulations not tabulated in the table.

Effective Dates

Figure 1 and Table 4 show the years when the various ordinances, regulations, or orders became effective. Data for the last complete year—1956—

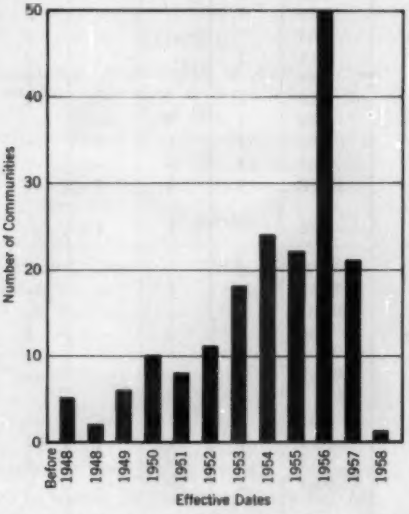

Fig. 1. Effective Dates of Ordinances, Regulations or Orders

Data for 1957 and 1958 are for actions reported as taken before Sep. 10, 1957. Information on effective dates received from 178 communities; no dates reported from 25.

show more than twice the number in 1954 or 1955. A definite upward trend appears from 1948 onward. Table 12 shows the years in which special charges were adopted. Before 1956, only 2 or 3 per year are indicated; in 1956, 21 were adopted; and in the first 6 months of 1957, 14 were adopted.

In determining effective dates, attempts were made to obtain the dates when controls were first instituted. In some instances, however, only the presently effective items—which may have been preceded by others, now abandoned rather than amended—were obtained.

TABLE 4

Effective Dates of Ordinances, Regulations, or Orders

Year	Number of Communities	Per Cent of Total	Population Group			
			A	*B*	*C*	*D*
1939	1	0.49	—	1	—	—
1941	1	0.49	—	—	—	1
1945	1	0.49	1	—	—	—
1946	1	0.49	—	—	—	1
1947	1	0.49	1	—	—	—
1948	2	0.98	—	1	—	1
1949	6	2.93	—	3	1	2
1950	10	4.88	5	—	1	4
1951	8	3.94	1	3	1	3
1952	11	5.40	6	1	1	3
1953	18	8.85	11	2	4	1
1954	24	11.80	16	4	—	4
1955	22	10.81	11	7	1	3
1956	50	24.56	27	8	5	10
1957*	21	10.63	9	5	5	2
1958*	1	0.49	1	—	—	—
Undated	25†	12.28	13	7	3	2
Total	203	100.0	102	42	22	37

* Excludes regulations adopted after Sep. 30, 1957.
† No report.

Unit Size and Conservation

As indicated in Tables 5 and 6 and Fig. 2, there are 159 communities in which conservation is required. In 48 of these (30.1 per cent) conservation is required on all new installations, regardless of size; in 142 (89 per cent) conservation is required on all of more than 5 hp or tons.

Many regulations specifically state that an installation will not be considered as conserved if the installation is

TABLE 5

Numbers of Communities Requiring Conservation, According to Unit Size

Size or Type Requiring Conservation	Number of Communities	Per Cent of Total	Population Group			
			A	*B*	*C*	*D*
All new installations	48	30.16	24	10	4	10
Over ¾ hp	2	1.26	1	1	—	—
1 hp or over	2	1.26	1	—	—	1
1 ton or over	1	0.63	1	—	—	—
Over 1 ton	2	1.26	—	1	1	—
2 hp or over	3	1.89	3	—	—	—
2 ton or over	3	1.89	1	—	—	2
Over 2 hp	1	0.63	—	—	—	1
Over 2 ton	5	3.14	2	—	1	2
Over 2 hp*	1	0.63	—	—	—	1
Over 2½ ton	2	1.26	1	—	—	1
3 hp or over	3	1.89	1	2	—	—
3 ton or over	9	5.66	7	1	1	—
Over 3 hp	1	0.63	1	—	—	—
Over 3 ton	20	12.58	9	4	3	4
Over 3 ton (nonconserved use in 1½ ton or less prohibited)	2	1.26	—	1	1	—
Over 3 ton (any use in 1½ ton or less prohibited)	1	0.63	1	—	—	—
3½ ton, or over	1	0.63	—	1	—	—
Over 3½ ton	1	0.63	1	—	—	—
5 ton or over	9	5.66	4	4	—	1
5 ton or over nonconserved (use in 1½ ton or less prohibited)	1	0.63	1	—	—	—
5 ton or over (any use in smaller units prohibited)	1	0.63	—	1	—	—
Over 5 hp	5	3.14	1	1	2	1
Over 5 ton	13	8.17	8	—	3	2
Over 5 ton (also 3 ton or less)	1	0.63	1	—	—	—
Over 5 ton (any use in 3 ton or less prohibited)	1	0.63	1	—	—	—
Over 5½ ton (any use in 3 ton or less prohibited)	1	0.63	1	—	—	—
6 ton or over	1	0.63	1	—	—	—
Over 6 ton	5	3.14	2	1	—	2
7½ ton or over	1	0.63	1	—	—	—
Over 7½ ton	1	0.63	1	—	—	—
10 ton or over	2	1.26	—	—	—	2
Over 10 ton	2	1.26	—	—	1	1
Over 10 ton (any use in 1½ ton or less prohibited)	1	0.63	—	1	—	—
11 ton or over (any use in 1½ ton or less prohibited)	1	0.63	1	—	—	—
50 ton or over	1	0.63	1	—	—	—
Demand, otherwise over 2.5 gpm	1	0.63	—	—	—	1
Demand, otherwise over 5 gpm	1	0.63	—	—	—	1
Over 2000 cfm rating	1	0.63	—	—	1	—
For over 200 sq ft	1	0.63	—	—	1	—
Total	159	100.00	76	30	19	34

* Unless waste is used for irrigation, in which case limit is 3 hp or over.

such that it is possible "to open a valve," "to bypass the conservation equipment," or "to operate" without recirculation through the conservation equipment.

Charges

Table 7 lists the types of special charges adopted by 59 communities, showing the amount of the charges and the bases of many special charges. It

TABLE 6

Conservation Requirements of Various Communities According to Air-Conditioning Unit Size

Size *hp* or *ton*	Communities	
	Number	Per Cent of Total
All (new units)	48	30
Over 1	55	35
2	69	43
3	110	69
5	142	89
10	157	99
50	159	100

should be noted that the 45 communities to which Detroit supplies water are reported to be compelled by contract to follow the Detroit requirements for charges. In this tabulation there are seventeen which report that they presently have such charges. Seven have reported that they do not presently have charges.

Charging $10 per ton per year are eleven communities and $20 per ton per year, nine communities. If the above mentioned Detroit group is considered as being only one water utility, then the group charging $10 per ton per year represents 26 per cent of all those with charges; and those at $20 per ton per year represent 21 per cent. In a few places, special charges are applicable only above specified unit sizes; in others, they are not applicable to existing units. Replacement, major repair, or any addition to existing installations place them in the category of new installations according to some specific regulations. In other situations this is the agreed interpretation.

It should be noted that although these tabulations generally show the total surcharge for the season, actually a great many are stated in the ordi-

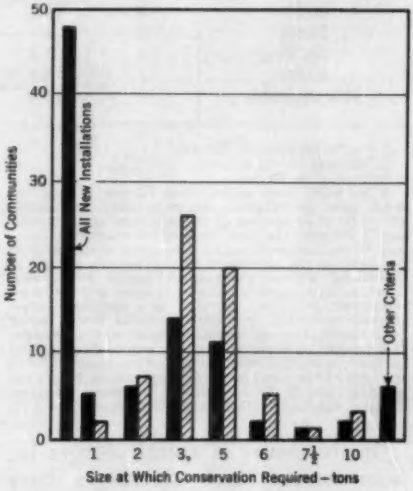

Fig. 2. Size of Installation at Which Conservation is Required

Data used were from 156 communities. Solid bars are for tons shown or more, shaded bars for "tonnages shown or greater."

nance or other limiting acts as proportionate charges for the 4 or 5 summer months. Those stated as a single charge for the season are usually billed before Jun. 1. In either of the preceding types of regulation, generally, rebates are provided when the units are converted to the conserved type before Aug. 1.

TABLE 7

Surcharges, Demand Charges, or Special Charges for Air-Conditioning Installations of 59 Communities

Charge per Ton per Year	Number of Communities	Per Cent of Total
$6.00	1	1.7
7.50	13*	22.0
8.00	4†	6.8
8.30	1‡	1.7
9.50	1‡	1.7
10.00	11	18.6
12.00	1	1.7
20.00	9	15.2
25.00	2	3.4
36.00	2	3.4
40.00	3	5.1
Miscellaneous	9	15.3

* Twelve supplied by Detroit.
† Two supplied by Detroit.
‡ Supplied by Detroit.
§ One each, each representing 1.7 per cent of the total, used the following charge systems: A monthly minimum of 20 per cent of the maximum of the preceding 11 months; the same for ¾ of the maximum (commercial and industrial only); a monthly minimum of 50 per cent of the maximum in the preceding May to September; separate metering and double the domestic rates; separate metering, domestic rates, and the meter minimum throughout the year as a standby charge; separate metering and noncommercial rates; higher peak-month rates and minimum charge where consumption exceeds twice the average or the preceding October to May; scheduled rates for conserved units of 10–15 per cent of the nonconserved; a flat rate of $7 per ton per year; and 25–36 cents per ton per month. One community, supplied by Detroit, made no report.

In the matter of special charges for nonconserved use, surcharges have generally been applied as some stated yearly or monthly sum, being charged for each ton of capacity in addition to payment for the water used. A different type of charge is now used in several communities. In Canada, Petersborough, Ont., adds a consumption charge to each monthly bill, "so that no monthly bill is less than 50 per cent of the maximum bill in the preceding June, July, August or September." Trenton, Ont., uses the same method to bill a minimum of ¾ the maximum in the preceding 11 months and Burlington, Iowa, requires that the minimum monthly bill equal 20 per cent of the maximum bill in the preceding 11 months. This is applied to all high seasonal users and thereby avoids the possibility of discrimination. Surcharges have been approved by public

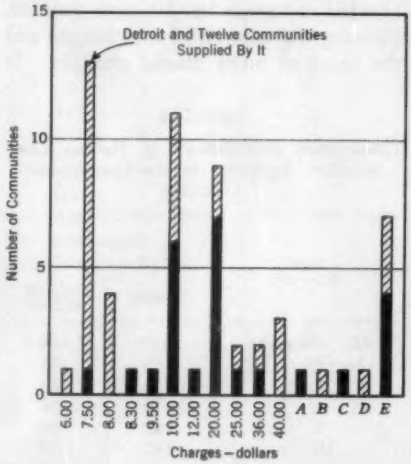

Fig. 3. Communities Using Surcharges, Demand Charges, Special Charges, or Regulations

Shaded and solid bars together represent total communities with charges; shaded portion, communities with charges but no conservation requirements; and solid portion, those with charges and conservation requirements. Thirty-four have charges only and 25 both charges and conservation requirements. Bar A *represents a charge of 25–36 cents per ton per month; Bar* B, *a monthly minimum of 20 per cent of the maximum of the preceding 11 months;* C, *a monthly minimum ¾ of the maximum of the preceding 11 months;* D, *a monthly minimum of 50 per cent of the maximum in the previous May–September period; and* E, *other special charges.*

service commissions. Whether or not the method of a monthly minimum has been approved by any regulatory body has not been specifically confirmed.

M. E. Driftmier, superintendent at Burlington, Iowa, has made the interesting suggestion that the ratio of current-month use to either average or minimum month use be used to determine the percentage to be added to the current monthly bill—the percentage being the product of the ratio of use and a percentage factor based on cost of capital improvements of plant and distribution necessitated by such increased usage. This would require payment for high use in the months of use rather than as a delayed penalty as in previously mentioned methods.

Table 8 shows that 25 communities which have surcharges, demand charges, or other special charges, also have regulations requiring conservation in some or all sizes—at least on new installations. In Table 7, six of the eleven in the $10 per ton per year group and

TABLE 8

Regulations, Surcharges, or Demand Charges in Communities Which Also Require Conservation

Surcharge or Demand Charge per Ton per Year	Number of Communities	Per Cent of Total	Population Group			
			A	*B*	*C*	*D*
$ 7.50	1	4.0	—	1*	—	—
8.30	1	4.0	—	1†	—	—
9.50	1	4.0	—	1*	—	—
10.00	6	24.0	3*	1* 1†	—	1*
12.00	1	4.0	1*	—	—	—
20.00	7	28.0	2† 1*	1*	3*	—
25.00	1	4.0	1†	—	—	—
36.00	1	4.0	1*	—	—	—
Miscellaneous‡	6	24.0	3*	1*	1†	1†
Total	25	100.0	12	7	4	2

* Conservation required on certain sizes.
† Conservation required on all new installations.
‡ One community imposes a 25–36 cents charge per ton per month; one, a monthly minimum of two-thirds of the maximum of the previous 11 months; and 4, other special charges. Each represents 4 per cent of the total.

seven of the nine in the group which charges $20 per ton per year, also have the conservation regulations.

Figure 3 illustrates the data of Tables 7 and 8, showing the numbers of communities having both charges and regulations and those with special charges only. The years when special charges were made effective are shown in Table 9.

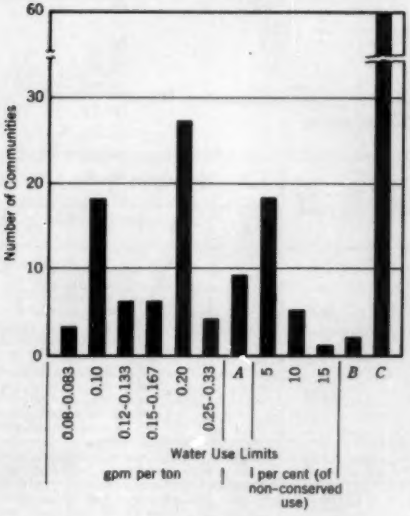

Fig. 4. Limits Where Conservation Is Required

Data shown are for a total of 156 communities. Bar A *is for communities using the model ordinance (see text, Reference 3); Bar* B *for those using any other criteria than those shown; and Bar* C, *communities with no specific limits.*

Water Use Limits

Of the 159 communities requiring conservation, 60 do not specify exact limits on water use. The limits specified by the other 99 are shown in Table 10 and Fig. 4. Of the 99, 27 per cent use 0.2 gpm per ton as a limit, 18 per cent use 0.1 gpm per ton, and another 18 per cent use 5 per cent of nonconserved consumption—which would fall between 0.1 and 0.2 gpm per ton. Nine others use the limits of the table suggested in the committee's model ordinance (*3*). In most instances, these limits also fall in the range 0.1–0.2 gpm per ton. A considerable number specify that allowable consumption shall be only that needed to compensate for losses by evaporation, windage, and similar effects. Some also mention flushing.

TABLE 9

Effective Dates of Special Charges

Year	Number of Communities	Per Cent of Total	Population Group			
			A	*B*	*C*	*D*
1949	1	1.7	—	—	1	—
1950	3	5.1	1	—	—	2
1951	1	1.7	1	—	—	—
1952	0	0.0	—	—	—	—
1953	2	3.4	1	1	—	—
1954	2	3.4	1	1	—	—
1955	5	8.5	3	1	—	1
1956	21	35.6	11	6	2	2
1957	14	23.7	4	6	3	1
1958	1	1.7	1	—	—	—
Undated	9	15.2	6	2	1	—
Total	59	100.0	29	17	7	6

A not uncommon provision is that, "if other than compressor type of refrigeration units are used, the consumption of water from the mains shall be limited to not more per ton of refrigeration produced than that allowed under these regulations for the compressor type."

Forty communities set specific maximum limitations on water use by the

TABLE 10

Limits Imposed by Communities on Water Use by Units With Conservation Devices

Limit	Number of Communities	Per Cent of Total	Population Group			
			A	*B*	*C*	*D*
0.08 gpm per ton	1	0.63	1	—	—	—
0.10 gpm per ton	16	10.07	7	4	2	3
0.12 gpm per ton	2	1.26	1	—	—	1
0.15 gpm per ton	2	1.26	1	1	—	—
0.20 gpm per ton	20	12.58	8	3	4	5
¼ gpm per ton	1	0.63	1	—	—	—
Model ordinance*	9	5.66	4	3	2	—
5.0 gph per ton	2	1.26	—	2	—	—
6.0 gph per ton	2	1.26	1	—	—	1
7.5 gph per ton	3	1.89	2	1	—	—
8.0 gph per ton	1	0.63	—	—	—	1
9.0 gph per ton	1	0.63	1	—	—	—
10.0 gph per ton	3	1.89	2	—	—	1
12.0 gph per ton	7	4.40	3	3	—	1
15.0 gph per ton	1	0.63	1	—	—	—
20.0 gph per ton	2	1.26	1	—	—	1
3.0 gpm per installation	1	0.63	—	—	—	1
6.0 gpm per system	1	0.63	—	1	—	—
5 per cent of nonconserved use	18	11.31	10	2	1	5
10 per cent of nonconserved use	5	3.14	1	1	—	3
15 per cent of noconserved use	1	0.63	1	—	—	—
No specific limit	60	37.72	31	9	11	9
Total	159	100.00	77	30	20	32

* See text, Reference 3.

TABLE 11

Limits Imposed by Communities on Water Use by Nonconserved Units

Limit	Number of Communities	Per Cent of Total	Population Group			
			A	*B*	*C*	*D*
1.0 gpm per ton	2	5.0	2			
1.5 gpm per ton	12	30.0	7	1	1	3
2.0 gpm per ton	17	42.5	8	3	3	3
2.0 gpm per ton*	5	12.5	3	2	—	—
3 gpm per ton	1	2.5	1	—	—	—
50 gph per ton	1	2.5	—	1	—	—
10 gpm per installation	1	2.5	1	—	—	—
Minimum discharge temperature† 80°F.	1	2.5	—	1	—	—
Total	40	100.0	22	8	4	6

* At water temperature up to 75° F; beyond, 3 gpm per ton.
† Automatic regulation of condenser.

nonconserved units. Table 11 shows that ¾ of these set limits not greater than 2.0 gpm per ton. One states a limit of 10 gpm for an installation; another requires that the water discharged from the condenser shall have a minimum temperature of not less than 80°F.

Very commonly, regulations require that the unit shall be equipped with a regulation device to control the flow according to the requirements of the condenser and to shut off flow when not required.

Others specify only a regulating device to limit flow to the specified maximum. A few communities specify that regulating devices shall be installed on all manufacturing processes (air conditioning included) in order to minimize waste which is prohibited. One prohibits waste, specifying that water which has been recooled and reused is not waste. This regulation also requires conservation on all new installations.

Existing Installations

Eighty-five of the regulations require that all existing installations shall conform to conservation requirements; three, that those over 2 tons conform; one, that those greater than 35 tons do so; one, conformity after any modification has been made; one, when repairs amount to more than 50 per cent of original cost; and three, when units have been "reinstalled."

Specific time for conformance is not stated in 24 instances, with one allowing "a reasonable time to comply." From 30 days to 9 months is allowed in 24; 1 year in 26; 18 months to 3 years in 12; and 5 years in one and 9 years in another. In a few instances, where a state of urgency existed, the date of conformance was made the same as the effective date of the ordinance.

Penalties

Ninety-five communities specify fines for violations of the ordinances or regulations, ranging upward to the maximums indicated in Table 12. These were contained in the documents specifically drawn up to cover air conditioning and refrigeration. Many more

TABLE 12

Maximum Fines Imposed for Violation of Air-Conditioning Regulations*

Fine	Number of Communities	Per Cent of Total	Population Group			
			A	*B*	*C*	*D*
$10	1	1.05	1	—	—	—
20	6	6.32	3	—	1	2
25	4	4.21	2	2	—	—
40	1	1.05	—	—	—	1
50	19	20.00	8	5	2	4
100	20	21.05	12	6	2	—
150	1	1.05	1	—	—	—
200	23	24.21	13	2	2	6
299	1	1.05	1	—	—	—
300	6	6.32	1	2	1	2
500	12	12.64	4	5	1	2
1,000	1	1.05	1	—	—	—
Total	95	100.00	47	22	9	17

* Other communities, in all probability, have fines provided in general codes.

—in fact, probably nearly all—communities have penalties prescribed in general codes. In three-quarters of these communities, penalties established were substantial. In most, prison sentences are provided as alternates or supplements, with 90 days common and some running to as much as a year.

Customer Protection

In the regulations of many communities it is specified that water use for air conditioning shall not adversely affect the water or sewer service of neigh-

TABLE 13—*Geographical Distribution of Regulations and Charges*

State	Communities				
	With Regulations Only	With Regulations and Special Charges	With Sepcial Charges Only	Number	% of Total
Arizona	Phoenix Tucson			2	0.98
Arkansas			El Dorado Pine Bluff	2	0.98
California	Fresno Monrovia Pasadena Pomona Red Bluff Riverside	Sacramento Woodland	Chowchilla Shafter Tulare	11	5.42
Colorado	Denver			1	0.49
Connecticut	Groton New Britain	Norwalk		3	1.48
Delaware	Wilmington			1	0.49
Washington, D.C.	Washington			1	0.49
Florida	Del Ray Beach Miami Beach Orlando Pensacola Tallahassee			5	2.46
Illinois	Batavia Clarendon Hills Elmhurst Highland Park La Grange Libertyville Riverdale Des Plaines Maywood	Evanston Hinsdale Wilmette	Champaign-Urbana Danville	14	6.91
Iowa	Ames Keokuk Rock Rapids Webster City	Atlantic	Burlington Centerville Waterloo	8	3.94
Kansas	Abilene Emporia Lawrence Manhattan Newton Ottawa Wichita	Salina		8	3.94
Kentucky	Hopkinsville Paducah			2	0.98
Louisiana	New Orleans Thibodeaux			2	0.98
Maryland	Washington (suburban)	Frederick		2	0.98
Massachusetts	Quincy	Weymouth		2	0.98
Michigan	Flint Grand Rapids Grosse Ile Township* Grosse Pte. Farms* Grosse Pte. Shores* Lathrop Village* Harpers Woods* Midland Oak Park Pontiac Roseville*	Hamtramck* Highland Park Lincoln Park* Grosse Pte. Woods*	Allen Park* Birmingham* Dearborn* Detroit Ecorse* Ferndale* Hazel Park* Nankin Township* Pleasant Ridge* Redford Township* Riverview* Royal Oak* Southfield Township* Trenton* Warren*	30	14.81

* Communities supplied by Detroit.

TABLE 13—*Geographical Distribution of Regulations and Charges (contd.)*

State	Communities				
	With Regulations Only	With Regulations and Special Charges	With Special Charges Only	Number	% of Total
Minnesota	Austin Marshall Moorhead South S. Paul			4	1.97
Mississippi	Greenville Greenwood Grenada Meridian			4	1.97
Missouri	Cape Girardeau Carthage Columbia Kansas City Kirkwood Rolla Webster Grove		Independence St. Charles St. Louis	10	4.93
Nebraska		Blair	Omaha	2	0.98
Nevada	Las Vegas			1	0.49
New Hampshire	Manchester			1	0.49
New Jersey	Caldwell Elizabeth Elizabethtown Essex Falls Jersey City Merchantville Newark N. Arlington Pensauken Perth Amboy Ramsey South Orange Verona Westfield			14	6.91
New Mexico	Albuquerque Hobbs			2	0.98
New York	Elmira Glens Falls Ithaca Jamestown Kingston Mt. Vernon Newburgh New York City Ossining Rochester Tarrytown Westchester County White Plains	Albany East Norwich Schenectady Vestal Webster		18	8.87
North Carolina	Warrenton			1	0.49
North Dakota	Bismarck		Fargo	2	0.98
Ohio	Cuyahoga Falls Lakewood Canton			3	1.48
Oklahoma	Oklahoma City Tulsa			2	0.98
Pennsylvania	Allentown Beaver Falls Chambersburg Lancaster Lansdale Lebanon Philadelphia Westview	Bethlehem	Ambridge	10	4.93

TABLE 13—*Geographical Distribution of Regulations and Charges (contd.)*

State	Communities				
	With Regulations Only	With Regulations and Special Charges	With Special Charges Only	Number	% of Total
South Carolina	Camden Greenwood Greer			3	1.48
South Dakota	Aberdeen	Rapid City Sioux City		3	1.48
Tennessee	Memphis Nashville Nashville (suburban)			3	1.48
Texas	Dallas El Paso Midland San Antonio San Angelo			5	2.46
Vermont	Brattleboro			1	0.49
Virginia	Arlington County			1	0.49
Wisconsin	Fond du Lac Fox Point Wauwatosa		Appleton Kaukauna	5	2.46
Wyoming	Cheyenne			1	0.49
Hawaii	Maui			1	0.49
Canada	Etobicoke, Ont. Galt, Ont. Guelph, Ont. Kingston, Ont. Montreal, Que Ottawa, Que. Sarnia, Ont. Stratford, Ont. Woodstock, Ont.	London, Ont. Trenton, Ont.	Peterborough, Ont.	12	5.92
Total	144	25	34	203	100.00

boring customers. It is vital that water utilities have the right to enforce such regulations in any vicinity. In this connection, the electric utilities which developed the system of demand charges now recognized as desirable by this industry have paralleled the above in another major step. They have established detailed code requirements which compel the use of expensive starter elements and motor designs to prevent excessive current inrush and the consequent effects—such as the dimming of lights. Geographical distribution of the regulations and special charges is shown in Table 13, with 37 states, Washington, D.C., Canada, and Hawaii represented.

Distribution by areas may be noted as follows: twelve in Canada (5.9 per cent), 146 in northern states (71.9 per cent), 44 in southern states (21.7 per cent), and 1 in Hawaii (0.5 per cent).

Areas in the northern United States seem to show two to three times as many communities with regulations as do southern areas. This may not be out of proportion to population and numbers of communities. Table 14 shows special charges and their effective dates in various communities. Table 15 lists communities contemplating some form of regulation.

TABLE 14

Communities With Special Charges for Air-Conditioning Water Use

Effective Date	State	Community	Charges
1953	Arkansas	El Dorado	Surcharge, nonconserved use of 3 tons or over —$2.50/ton/mo, May–Sep.
1953		Pine Bluffs	Surcharge, nonconserved use of 3 tons or over —$2.50/ton/mo, May–Sep.
1951	California	Chowchilla	Flat water rate—$7/ton/yr.*
1950		Sacramento†	Rate schedule rates—with tower, 15% and with evaporative condenser, 10% of nonconserved rate.*
1955		Shafter (public utility district)	Air cooling, 50 cents/ton/mo; cooling and heating, $1/ton/mo if nonconserved
1957		Tulare	$2/ton/mo, May–Sep. All new installations, separately metered and billed. Oct. 1–Apr. 30 billed as 1 mo.
1956		Woodland†	No charge, conserved under 7.5 tons and residential. Others, surcharge of 25–36 cents/ton/mo, increasing with size. Additional 20% for sewer use.
1956	Connecticut	Norwalk†	Surcharge, $25/ton/yr.
1956	Illinois	Champaign-Urbana	Surcharge, nonconserved use—$25, May 1, 1957; $35, May 1, 1958; $40, May 1, 1959.
1957		Danville	Surcharge, nonconserved use—$25/ton/yr.
1956		Evanston†	Surcharge, existing installations of over 5 tons —$20/ton/yr.
1956		Hinsdale†	Surcharge, $3/ton/quarter.
1956		Wilmette†	Surcharge, $10/ton/season.
1956	Iowa	Altantic†	Surcharge, nonconserved used—$10/ton/yr.
		Burlington	Minimum bill 20% of maximum bill of previous 11 mo.
1950		Centerville	All water billed at noncommercial rate.*
1957		Waterloo	Surcharge, nonconserved use over 3 tons—$2.50/ton/mo, Jun–Sep.
1957	Kansas	Salina†	Surcharge, nonconserved use—$2.50/ton/mo, Jun.–Sep.

* Not considered surcharge or demand charge.
† Require conservation in some or all sizes in new installations.

TABLE 14—*Communities With Special Charges for Air-Conditioning Water Use (contd.)*

Effective Date	State	Community	Charges
1955	Maryland	Frederick†	Surcharge, nonconserved use—$10/ton/yr; conserved use—$1/ton/yr.
1955	Massachusetts	Weymouth†	Domestic rates and meter minimum through year as standy charge.*
	Michigan	Allen Park	Same as Detroit.
1956		Birmingham	Surcharge, nonconserved use—$8/ton/yr, May 1–Sep. 30. Charge increasing to maximum in 1961.
1957		Dearborn	Same as Detroit (contract).
1956		Detroit	Surcharge, nonconserved use—$7.50/ton/yr, May 1–Sep. 30. Charge increasing to maximum in 1961.
		Ecorse	Same as Detroit.
1956		Ferndale	Same as Detroit.
1957		Grosse Pointe Woods†	Sliding scale to maximum of $7.50/ton/yr, in 1962. Similar to Detroit.
1957		Hamtramck†	Surcharge, $8.30/ton/yr.
1957		Hazel Park	Same as Detroit.
1956		Highland Park†	Surcharge, units over 5 tons—$20/ton/yr. Effective Mar. 29, 1957.
1957		Lincoln Park†	Surcharge, $9.50/ton.
1956		Nankin Township	Same as Detroit.
		Pleasant Ridge	Same as Detroit.
		Redford Township	Demand charge, nonconserved use.
1956		Riverview	Same as Detroit.
1957		Royal Oak	Sliding scale to maximum of $8/ton/yr in 1961.
		Southfield Township	Same as Detroit (contract).
1956		Trenton	Same as Detroit.
		Warren	Same as Detroit.
1955	Missouri	Independence	Higher peak-month rates and minimum for customers (1.5-in. service or larger) whose consumption exceeds twice the average in previous Oct.–May.*

TABLE 14—*Communities With Special Charges for Air-Conditioning Water Use (contd.)*

Effective Date	State	Community	Charges
1954	Missouri (*cont.*)	St. Charles	Surcharge, nonconserved use—$10/ton/yr.
1957		St. Louis County	Surcharge, $40/ton/yr.
1956	Nebraska	Blair†	Surcharge, $36/ton/yr.
1956		Omaha	Surcharge, $36/ton/season
1950	New York	Albany†	Demand charge, nonconserved use—$10/ton/yr; conserved—$2/ton/yr.
1956		East Norwich† (Jericho Water District)	Demand charge, nonconserved use—$20/ton/yr.
1955		Schenectady†	Demand charge (air conditioning), nonconserve use—$20/ton/yr; conserved use—$5/installation/yr.
1956			Demand charge (refrigeration) nonconserved use—$10/hp/yr; conserved use—$5/installatir.on/y
1956		Vestal†	Demand charge, nonconserved use—$20/ton/yr; conserved—$5/installation/yr.
1957		Webster†	Demand charge, nonconserved use—$20/ton/yr; conserved—$5/installation/yr.
1954	North Dakota	Fargo	Surcharge, $10/ton/yr. ($2.50 each month, Jun.–Sep.)
	Pennsylvania	Ambridge	Minimum of $40/ton/yr.
		Bethlehem†	5 cents /1,000 gal for storm sewer discharge.*
1956	South Dakota	Rapid City†	Surcharge, nonconserved use—$10/ton/yr.
1957		Sioux City†	Surcharge, over 5 tons—$20/ton/season.
1956	Wisconsin	Appleton	Surcharge, nonconserved use—$20/ton/yr.
1958		Kaukauna	Surcharge, nonconserved use—$20/ton/yr.
1949	Canada	London, Ont.†	Nonconserved use separately metered; double domestic rates.*
1956		Peterborough, Ont.	Consumption charge added so that no monthly bill less than 50% maximum bill of preceding Jun.–Sep.
1957		Trenton, Ont.†	Commercial and Industrial use only; Demand charge—minimum monthly bill equal to ¾ the maximum of any one of preceding 11 mo.

* Not considered surcharge or demand charge.
† Require conservation in some or all sizes in new installations.

TABLE 15

Communities Reporting Consideration of Special Charges or Regulations for Air-Conditioning or Refrigeration Water Use

California	*New Jersey*
Anaheim	Edison Township
Fullerton	Glen Ridge
Glendale	Hillside
San Bernardino	Montclair
San Fernando	Union
Connecticut	*New York*
Hartford	Penn Yan
Southington	Utica
Georgia	*North Carolina*
Brunswick	Lexington
	Wilson
Illinois	*Ohio*
Chicago	Alliance
Elgin	Canton
Moline	
Oak Lawn	*Oregon*
St. Charles	Hood River
Indiana	*Pennsylvania*
Delphi	Fredericktown
Iowa	*Virginia*
Sioux City	Norfolk
Michigan	*Wisconsin*
Clawson	Milwaukee
Saginaw	Racine
	Wausau
Minnesota	
St. Louis Park	*Canada*
St. Paul	Burlington, Ont.
Nebraska	Cooksville, Ont.
McCook	East Sandwich, Ont.

Purpose of Regulations

Eight communities indicated that the primary purpose of regulation was solution of sewer system difficulties. Seventeen indicated that both water and sewer system conditions necessitated the regulations. Ninety others indicate that the primary consideration was of the water system only. The committee has no way of knowing how many of the 90 were considering sewerage conditions as well, nor what portion of the remainder—approximately 40 regulations—were prompted by water or by sewer conditions. An excellent statement of reasons for regulation is that embodied in the Newton, Kan., ordinance:

WHEREAS, The operation of water-cooled air-conditioning equipment for changing the temperature or humidity of the air has produced such an extreme demand on the city's water system and an excessive load on the sewage plant of the city of Newton; and

WHEREAS, The uncontrolled, unconserved use of water as a coolant in air-conditioning systems is a waste of a natural resource; and

WHEREAS, It is not economically feasible to provide sufficient sewage and plant facilities to service the additional load created by uncontrolled, water-cooled type air-conditioning systems; and

WHEREAS, In the best interests of the public and its water and sewage systems it becomes necessary to regulate the use of water for such purposes and to require the conservation of water and the elimination of unnecessary waste; now, therefore, be it

Ordained . . .

Miscellaneous Requirements

One city ordinance makes it a violation to have in possession between May 15 and Oct. 1 any installation of a capacity greater than 2 tons, without conservation, and "actually attached to the water system," unless "officially sealed off from the municipal water supply system."

Another city specifies: "Space-cooling systems shall be operated during the months June–September in such manner that the inside temperature shall at no time be more than 10° lower than the prevailing outside temperature."

Metering

One city requires that air-conditioning units of 50-ton capacity or greater be "separately metered" and another requires that *all* air conditioning be "separately metered." A third requires that all air conditioning be "submetered" and one specifies that the service and meter size for air conditioning shall not exceed 1 in. Those with special charges based on water consumption also require metering.

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New Reservoirs at Tacoma, Wash.

George E. Hopkins

A paper presented on May 3, 1957, at the Pacific Northwest Section Meeting, Tacoma, Wash., by George E. Hopkins, Chief Civil Engr., Water Div., Dept. of Public Utilities, Tacoma, Wash.

TACOMA, Wash., has recently completed two new concrete-lined reservoirs: one of 50-mil gal capacity, known as the Portland Avenue Reservoir (Fig. 1), located in the city to provide additional storage and fire service to the Tide Flats industrial area, and one of 100-mil gal capacity, known as McMillin Reservoir No. 2 (Fig. 2), located 16 miles southeast of the city, which doubles the storage of the gravity supply system. This additional gravity storage is needed to provide a stand-by supply at times of freshets in the Green River which makes the water unfit for use. During these periods the additional water needed is pumped from wells located within the city. This 100-mil gal additional storage is approximately 2 days' supply for the city, which means a substantial saving in pumping costs.

There is nothing revolutionary about the design of either reservoir, the same basic principles having been used before by engineers in the design of reservoirs elsewhere. There were, however, numerous modifications made to simplify construction and overcome certain problems which have been brought to light in the operation of present reservoirs.

Portland Avenue Reservoir

Prior to the construction of the Portland Avenue Reservoir, the Tide Flats industrial area was served only from the Hood Street Reservoir, which has a capacity of 13 mil gal. This was obviously inadequate, since daily consumption in the area served averages of about 35 mgd, which meant using nearly three times the reservoir capacity each 24 hr. The St. Regis Paper Company at present uses 21 mgd, and plant expansions are now under way which will require an ultimate additional supply of approximately 13 mgd. These factors made the increased storage a necessity.

The site of the Portland Avenue Reservoir was selected with the thought in mind of being able to construct a reservoir with the spill elevation the same as the Hood Street Reservoir. The location chosen was ideal in this respect, and in addition the area was comparatively undeveloped, which kept the cost of land acquisition within reasonable limits. The site is on a hill above Portland Avenue between East 38th Street and Fairbanks Street. The west side of the reservoir is entirely in cut. The original ground sloped to the east, and a cut of approximately 5 ft was necessary on the east side. Excavated material from the reservoir was deposited on the lower (east) side, built up in layers and compacted to 95 per cent of maximum density of the material to form an embankment. This embankment has a 3:1 slope on the

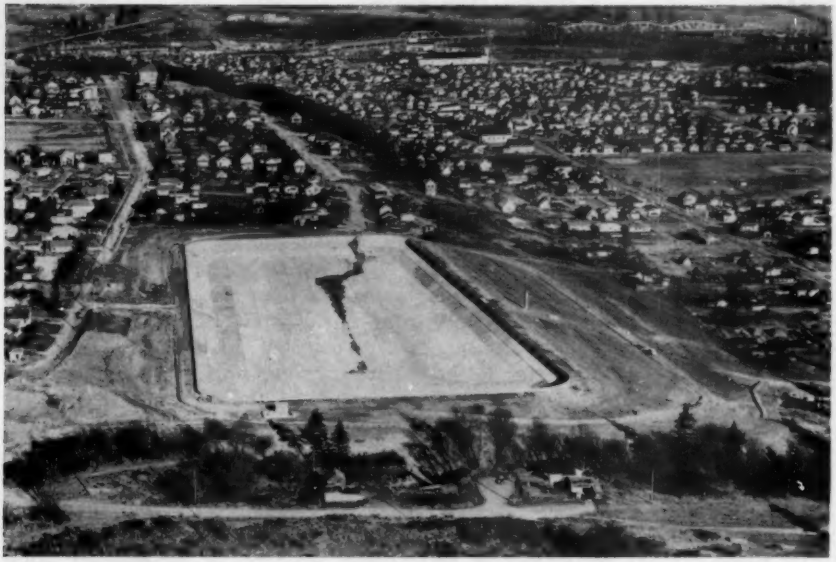

Fig. 1. Portland Avenue Reservoir, as Completed

Fig. 2. First Water Entering McMillin Reservoir

outer face and a 2:1 slope inside the reservoir, and is topped by a berm around the reservoir 22 ft wide. The excess of excavated material over that required for the embankment was 107,000 cu yd. In cooperation with the city public works department, some 60,000 cu yd of this material was hauled several blocks and used to build a street fill replacing an old wooden bridge across a deep gulch at that location. The balance of the excess excavation was wasted below the toe of the reservoir slope on the site and later bladed to a uniform grade.

It was apparent from preliminary test borings that constant ground water seepage would be present on the east side of the reservoir. To prevent the accumulation of water under the reservoir lining, a grid system of concrete semicircular 4-in. radius drains with side openings and gravel backfill were constructed under the slabs. A 3-in., continuously poured, concrete slab covers the drains, and 2-in. washed gravel was placed on each side of the drains, which were arranged to slope to a central collecting drain similarly constructed and having a 7-in. radius. The collecting drain discharges into a 14-in. pipe leading to the waste line from the reservoir spillway. A weir chamber was built east of the reservoir with two vee-notched weirs for measuring the spill, the subdrainage, and leakage, if any. Collecting drains are spaced every 30 ft transversely. There are four longitudinal collecting drains under the bottom slabs of the reservoir and one at the midpoint of the slope all around. Floor slabs in the reservoir are 30 ft square except at the perimeter. The subdrains were placed under the expansion joints to act as supports for the slabs. At joints where no subdrains are present, slabs are supported on solid concrete ribs 8 in. deep by 11 in. wide. Slabs are 6 in. in thickness and reinforced with No. 3 bars on 6-in. centers each way. Slabs are separated by expansion joints with copper water stops, above each of which is a strip of ½-in. premolded expansion joint material and a 1½-in. seal of rubberized asphalt.

A parapet wall (Fig. 3) was constructed at the top of the slope. The wall was built in 30-ft sections with expansion joints lining up with those in the reservoir slope. Joints in the wall were similar to those between slabs, except that the copper water stops were placed in the center of the wall and the joints were sealed with a rubber compound which bonds to the concrete. After thorough cleaning of the joint a primer was brushed into the joint and the compound applied through a pressure nozzle. A catalytic agent was added to the compound before application, causing the material to cure in about 48 hr under normal temperatures, forming a firm, elastic joint.

The parapet wall was designed to provide a vertical section extending 3 ft below the spill elevation to minimize the growth of algae along the wall. The top of the parapet is 3½ ft above the operating level of the reservoir and above the ground surface on the outside to provide a measure of protection from debris carried by wind and small animals.

In building the reservoir, several construction problems were encountered. In reservoirs previously constructed the semicircular concrete subdrains were covered with 3-in. precast slabs built in 2-ft sections. The plans of the Portland Avenue Reservoir called for the same method of construction. The contractor suggested

pouring the cover slabs continuously by extending the drain side forms 3 in. higher. The drains were poured using a semicircular wooden form for the channel with cross members to provide the side openings. As soon as the concrete was sufficiently set to be stable, the semicircular forms were removed, leaving the side forms in place, and the surface was finished with a special tool shaped to the circumference of the drain. When the concrete in the drain had cured, asbestos-cement sheets of $\frac{3}{16}$-in. thickness were laid over the channel, steel was placed, and the slab was poured.

It was obvious that more efficient operation could be maintained if a longitudinal row of floor slabs could be poured continuously the full length of the reservoir. This also presented the problem of holding the expansion joint material in place while pouring, which was solved by nailing a light metal strip $3\frac{3}{4}$ in. wide to the premolded material and extending the full width of the

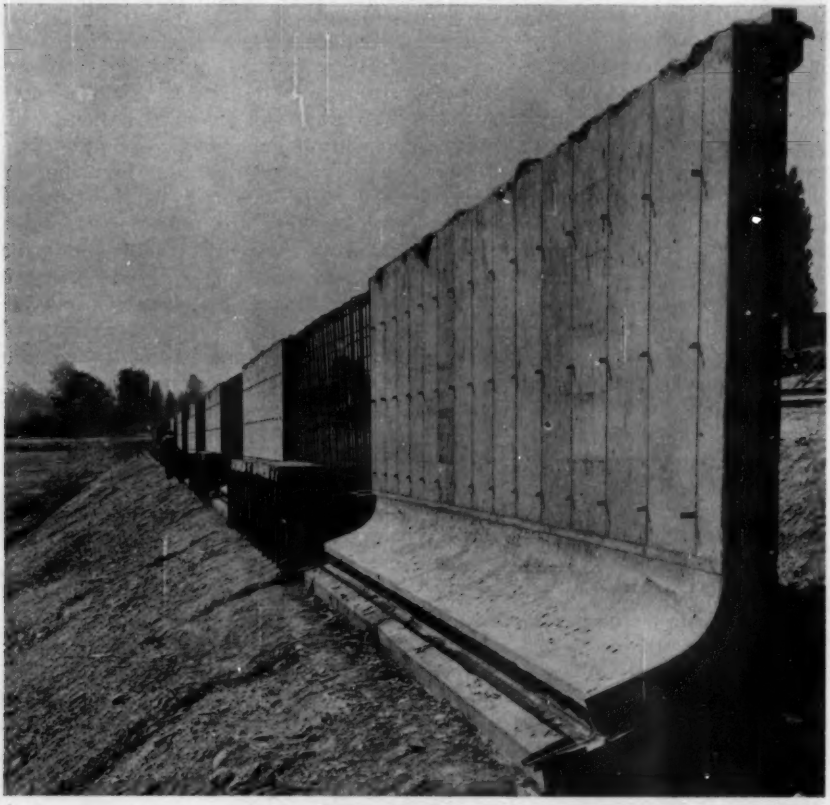

Fig. 3. Section of Parapet Wall, Portland Avenue Reservoir

slab. The metal strips were anchored to the reinforcing steel by means of No. 4 wire stubs at 2-ft intervals, alternating top and bottom. The stubs were tack-welded to the metal strip and the reinforcing steel. This method was actually developed by the contractors for McMillin Reservoir, but it was also used at Portland Avenue.

Ready-mixed concrete was used, and it was placed by a crane and bucket, supplemented at times by concrete buggies. As much as 400 cu yd was poured in one day by this method. Concrete was vibrated and compacted by means of a gasoline-powered roller screed. On the reservoir slopes a hopper-type screed was tried, but this method proved unsatisfactory. In the end the roller screed was adapted for side-slope work also by tilting the motor so that it continued to operate in a horizontal position and by adding metal fins to prevent the fresh concrete from sliding down the slope. The screed traveled in a longitudinal direction along the slope and was kept from sliding by being tied to a carriage that traveled along the parapet wall. This method was also used first at McMillin Reservoir (Fig. 4) and later adopted at Portland Avenue. Concrete slump on the slopes was held to not over 2 in.

The Portland Avenue Reservoir is served by a 30-in. steel supply main connecting to one of two gravity supply mains, and the outlet is a 42-in. steel main connected to a 48-in. main serving the Tide Flats industrial district. A 30-in. steel bypass was also constructed around the reservoir, insuring continuous service if the reservoir is not in use.

Water reaches the reservoir site at a pressure of 125 psi. To reduce the pressure before the water enters the reservoir, a pressure-reducing manifold was installed, consisting of 24-in. and 36-in. steel headers connected by six tapered nozzles and controlled by six 6-in. plug valves. This assembly is supplemented by a bypass in which a 16 × 12-in. pressure-reducing valve is installed, permitting isolation of the manifold assembly for inspection or repairs without interrupting service to the reservoir. Flow is measured by a 36-in. meter.

The reservoir has an average length of 933 ft and an average width of 401 ft. The average depth to operating level is 21.5 ft and the total capacity is 50 mil gal.

Principal quantities for all contracts were: 26 acres of clearing and grubbing, 213,561 cu yd of excavation, 10,550 cu yd of concrete, 805,000 lb of reinforcing steel, 32,000 ft of expansion joints, 5,051 ft of 42-in. steel pipe, 3,607 ft of 36-in. steel pipe, 780 ft of 24-in. steel pipe, two 36-in. metal-seated butterfly valves, six 24-in. metal-seated butterfly valves, three 18-in. metal-seated butterfly valves, and one 16 × 12-in. pressure-reducing valve.

The total cost of all contracts was $1,137,755. Of this total, the reservoir proper cost $715,289, and the interconnecting pipelines, $422,466. Land cost was $64,182. A fence now under construction is estimated to cost $30,000.

McMillin Reservoir

Construction of McMillin Reservoir was originally planned by the water division for 1960, but the construction of the Eagle Gorge Flood Control Dam by the US Army Corps of Engineers above the headworks made an earlier construction date advisable, in order to have a reserve storage supply available during periods of high turbidity caused by equipment working in the river. To

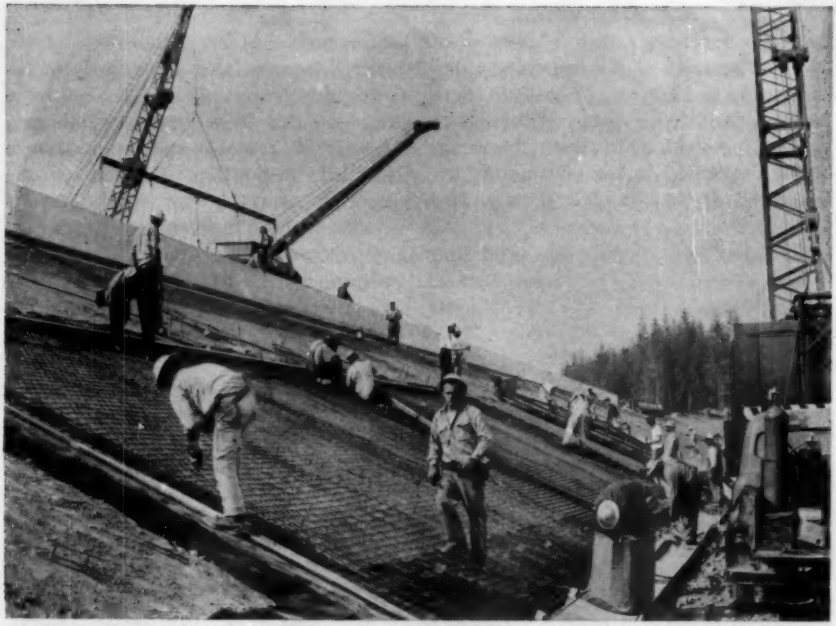

Fig. 4. Paving the Slope of McMillin Reservoir

In the background can be seen the roller screen, adapted for side-slope operation.

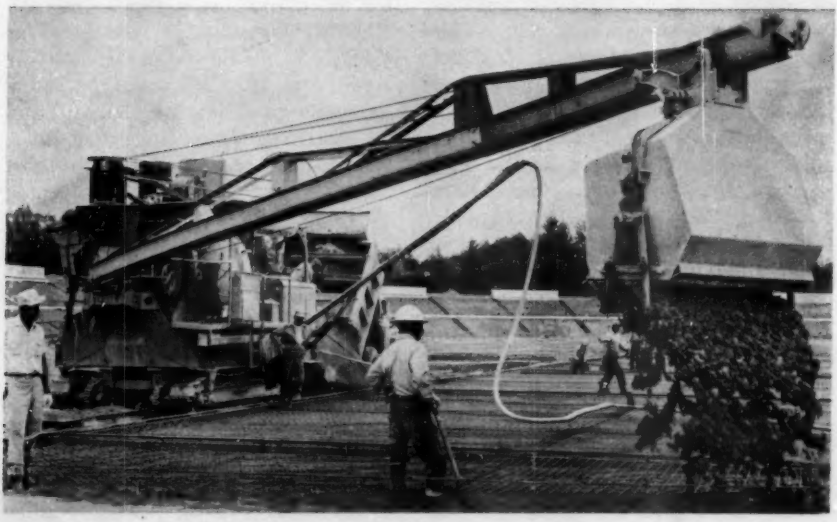

Fig. 5. Paving Machine With 40-ft Boom at McMillin Reservoir

this end, the Army engineers entered into an agreement with the city by which they would pay the cost of interest on the investment and the maintenance cost of the reservoir until 1960 if the reservoir were built immediately.

The excavation and pipe installation were contracted separately from the main reservoir construction, the contract being awarded on Feb. 8, 1956. On May 9, the main contract was awarded, with a completion date of Oct. 31, 1956. As work on the contract progressed, it became more and more evident that the city was fortunate to have a firm doing the work which scheduled operations with the completion date always in mind and turned out a first-class job, substantially completed on October 31.

Principal quantities for all contracts were as follows: 47 acres of clearing and grubbing, 346,000 cu yd of excavation, 27,500 cu yd of trimming and fine grading, 16,633 cu yd of concrete, 1,300,000 lb of reinforcing steel, 44,700 ft of expansion joints, 1,550 ft of 60-in. steel pipe, 75 ft of 48-in. steel pipe, 1,150 ft of 36-in. steel pipe, 720 ft of 24-in. steel pipe, 850 ft 12-in. concrete pipe, four 48-in. rubber-seated butterfly valves, and one 36-in. rubber-seated butterfly valve.

The reservoir is 1,100 ft long and 732 ft wide, with an average depth of 20.7 ft.

The total cost of the reservoir and piping complete was $1,371,048. Of this total, the reservoir proper cost $970,073, and other installations, $400,975.

The site for this reservoir was already owned by the city but it was necessary to purchase an additional 15½ acres for disposal of waste material from the excavation. The bottom and operating levels of the reservoir were set at the same elevations as those of the existing reservoir so that the complete installation would operate as a unit. Of the 346,000 cu yd of excavation, 40,000 cu yd were compacted to form an embankment 20 ft wide on top with 2:1 slopes on both the reservoir side and the outside. The balance, 306,000 cu yd, was deposited outside of the embankment and finished to a uniform slope of 1 per cent away from the reservoir. Surface drainage was intercepted by an open ditch around the outside of the property.

The reservoir is fed by an extension of the inlet to the existing reservoirs, which are connected to the main gravity supply from Green River and the outlet of the new reservoir is connected to the existing outlet by a wye branch. Numerous piping revisions were made, and several new valves were installed in existing lines to provide an integrated operation of both reservoirs.

Design details are similar to the Portland Avenue Reservoir with the following exceptions: Standard slabs were 40 ft square, and 44–33 welded wire mesh fabric with a No. 4 perimeter bar at the slab edges was used as slab reinforcing instead of rods. For reasons of economy, a shorter parapet wall was designed with the water level at the top of the reservoir slope, maintaining a 3-ft freeboard above the water level and the ground on the outside of the wall.

Concrete aggregates were available on city property near the site. Washing and batching plants were set up by the subcontractors who furnished the concrete. A paving machine equipped with a 40-ft boom (Fig. 5) was used in pouring the bottom slabs. To use a boom of this length required considerable alterations to counterbalance the machine for a load at the end of this extension. As much as 700 cu yd per day were poured by this method. A

40-foot roller screed was used for vibrating and compacting the concrete in the slabs, and a shorter screed of the same type used on the slope (Fig. 4).

Transverse subdrains were spaced at 80 ft, except that in some areas a 40-ft spacing was adopted when it became apparent that these areas were subject to considerable seepage. Subdrain construction was carried on in a manner similar to that used at Portland Avenue, except that curved sheet metal forms with steel crossbars were used to form the channels and side openings.

The outlet is protected by a removable metal screen assembly mounted on a structure built into the slope of the reservoir. The structure also includes a ramp for moving cleaning equipment in and out of the reservoir.

Engineering on both reservoirs was done by the Department of Public Utilities, Water Division. Dean Barline is director of utilities, and J. A. Kuehl is water superintendent. The design and construction of the reservoirs were under the author's direction. Earl H. Meyer was resident engineer for the Portland Avenue Reservoir and Kenneth F. Olson for the McMillin job. W. A. Kunigk, since retired, was water superintendent during the planning stages and the early part of the construction work.

Construction of the Union River Dam at Bremerton, Wash.

C. Cliff Casad and John W. Cunningham

A paper presented on May 2, 1957, at the Pacific Northwest Section Meeting, Tacoma, Wash., by C. Cliff Casad, Supt., Water Dept., Bremerton, Wash., and John W. Cunningham, Cons. Engr., John W. Cunningham & Assocs., Portland, Ore.

THE major claim for distinction of Bremerton, Wash., is the Puget Sound Navy Yard, a diversified industry of major proportions, situated there. During years of peace, the yard has provided a stable and growing payroll, sustaining a population currently estimated at 30,000 within the city limits plus that of substantial suburbs—all serviced by the city water system. In addition, the navy yard is a wholesale water customer with a consumption approximately equal to the domestic use.

Currently the average annual consumption approaches 8 mgd, with a daily summertime demand at about 12 mgd. Bremerton, however, must always consider and plan for conditions such as were imposed during the recent world war, when a population increase to 75,000 was accommodated by temporary housing of various types. Fortunately, the water demand did not increase in proportion to the population and additional well supplies were brought in to meet the demands of the period.

Bremerton is not favorably situated with respect to surface water. It lies on a peninsula which approaches the description of school geographies—almost completely surrounded by water. Watersheds are limited and streams small and scattered. Water must be taken where it can be found and, over a period of years, Bremerton has developed and uses five surface water supply sources in addition to seven wells. The one most recently developed is the Union River, which has a watershed area of only 3.2 sq mi but which, as a result of topographic conditions, is quite productive and, with storage, offers an average annual supply of over 7 mgd. Storage is costly, and the Union River Dam which was built in 1955 and 1956 to control the flow of this stream cost $1,400,000 for 1.3 bil gal capacity, or $1,080 per million gallons.

Exploration and Geology

The Union River canyon is relatively narrow (see cover) with prominent rock outcroppings which suggest a masonry dam as most suitable. Earth and rock fill dams were considered and abandoned because of a lack of impervious sealing material. After the most favorable location was determined, many surface test pits were made, together with a total of 814 ft of diamond drill borings in 23 drill holes.

The general underlying rock in the area is classified as amygdaloidal basalt. The name refers to the prevalence of

almond shaped inclusions, originally gas bubbles, which are now filled with calcite. The rock apparently was cooled quite rapidly and does not have the structure and troublesome contraction joints so often found in basalt. Although it is relatively tight, it has been subjected to stresses causing faults, now inactive and the dam site is crossed diagonally by a dike of entirely different character—a light colored felsite. All of these conditions pointed to the need of a careful follow-up during the construction period and the specifications provided for special treatment at faults and for pressure grouting of the foundation.

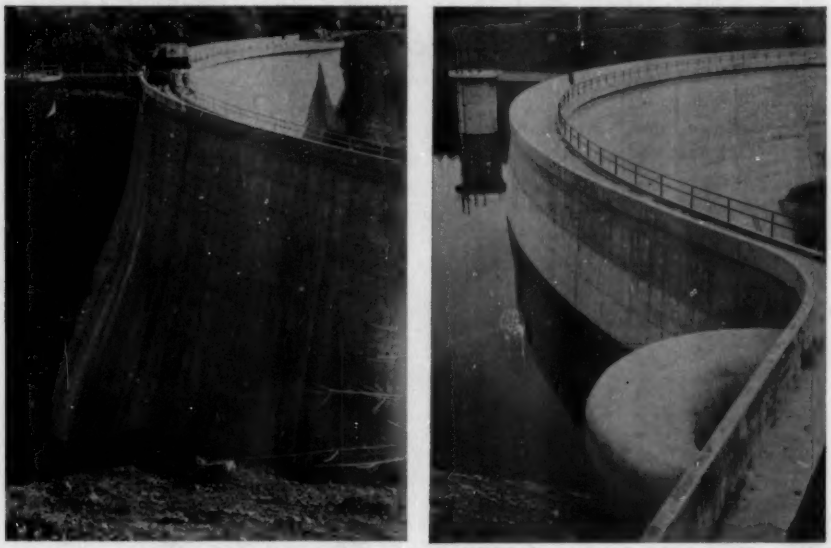

Fig. 1. Two Views of Dam

At left, upstream face is exposed; at right, view of filled dam shows "glory hole" type of spillway in foreground. Outlet tower is visible in both views.

Design Calculations

Arch dams have been a subject for extended engineering study and the literature on the subject is voluminous. Particularly detailed work has been done by the US Bureau of Reclamation and their methods have been recorded in detailed manuals and various papers by their staff and consultants. These methods have been summarized in a volume by Creager, Hinds, and Justin (*1*).

All available information was utilized in the design work for the Union River Dam. The decision was made early to use the variable-radius type of arch dam, which has a vertical lower face at the center line with radii varying uniformly from bottom to top. This was believed to offer economy combined with reasonable simplicity in layout and forming. Original sections were worked out by the cylinder theory and stresses were determined by

abridged methods of trial load analysis. Compression stresses in the arch were limited to 450 psi and tensile stresses to 150 lb. As an earthquake precaution, the stress limitations were set 10 per cent higher than the original figures.

To shorten the arch span, the thrust from the topmost 12 ft of the arch is carried by massive thrust blocks which are extended tangentially and dropped downward to bearing against the abutment rock. Closure to the canyon walls for this portion of the dam is made by the use of short gravity walls.

The dam is about 132 ft high from stream bed to roadway level, but solid rock under the middle of the arch extends down about 65 ft under the stream bed, making the structural height 197 ft. The thickness varies from 9 ft at the top to a maximum of 56 ft at the base. The construction required 107,800 cu yd of excavation—mainly in rock—and 46,440 cu yd of concrete.

Spillway and Outlet

Because of the smallness of the drainage area, the dam will exercise a high degree of storage control. To control the floods, however, which may conceivably occur when the reservoir is full, a semicircular "glory hole" type of spillway (Fig. 1) is provided, with a capacity which is double that of any recorded flood. No material damage would ensue if the dam were overtopped.

For controlled discharge of the stored water there is an outlet tower—its base integral with the dam—with racks and slide gates at different levels. The outflow is controlled by a downstream valve of the sleeve type * in a house below the dam (Fig. 2). Draft of water is measured and recorded by a venturi meter ahead of this valve. Discharged water flows down the river bed for half a mile to a low dam which diverts it into the supply system.

Pressure Grouting of Foundation

Although rock conditions in the foundations appeared exceptionally good, full additional precautions were taken with pressure grouting. This had two objectives; the supporting strength of the rock was improved, particularly in the abutments, and a complete grout curtain prevented or, at least, minimized percolation through the underlying formations.

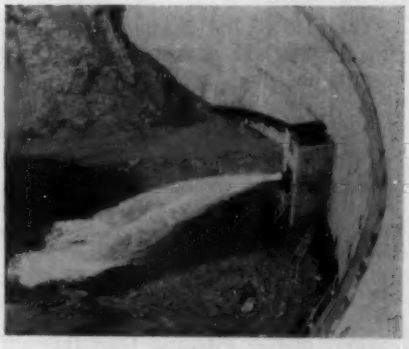

Fig. 2. Valve House

Outlet jet seen from top of dam.

Conventional grouting equipment provided, consisted of diamond drills using plug bits, grout mixers and pump, packers, and accessories. After a hole had been drilled, it was water tested for leakage. By using the packers, it was possible to identify the for-

* Valve used is a Howell-Bunger type, product of the S. Morgan Smith Co., York, Pa.

mations and locations where water losses occurred. The hole was then pressure grouted with cement grout and the rate and amount of grout acceptance was recorded. After primary grouting, secondary and sometimes tertiary holes were drilled, water tested to determine the effect of primary grouting, and themselves grouted to refusal. This rather tedious process was coordinated with the excavation in order to minimize delay in the succeeding concrete placement.

Excavation

The size of the Union River Dam did not warrant any special cableway installation and standard equipment units were used throughout. It was found possible to build a construction road up the canyon, along which excavated material from the banks was worked down to the bottom of the slope, loaded, and hauled to the dump. The river, which during the summer season should not be called a river, was diverted first through an earthen channel at one side and later through a wooden flume spanning the excavation. For the base of the dam, the gravel and blasted rock was removed and loaded by drag lines.

Concreting

Specifications for concrete called for 1.15 bbl/cu yd of low-heat portland cement with a 3-in. maximum aggregate and with the coarse aggregate in three sizes. The objective was a 3,000-psi concrete, and this was, in general, substantially exceeded. There happened to be an efficient batching plant within 6 mi of the site, and the contractor elected to use ready-mix trucks rather than install his own concrete plant.

A problem in any concrete job of substantial proportions is the shrinkage that occurs during setting and subsequent cooling. This is a particular problem in a water holding structure such as a dam. The methods used in the Union River Dam were by no means original and conformed to the established engineering practices for such structures. The dam was divided into blocks or obelisks by transverse vertical contraction joints at 45-ft intervals which extended from the foundation to the top of the concrete. These blocks were keyed together by vertical keyways in zigzag form and the joints were made tight against passage of water by copper water or grout stops upstream and downstream. Between the vertical joints, the concrete was placed in 5-ft lifts, working from the foundation to the top. After each of these lifts had set, and before the pour was started on the next, the surface was thoroughly cleaned and covered by a layer of grout to insure a horizontal bond. At every fifth lift, horizontal copper grout stops and grout grooves were provided.

During concrete placement, internal temperatures were measured by thermometers inserted in pipes which extended into the interior of the dam. Maximum temperatures of about 110°F were observed. The concrete gradually cooled at rates determined by the thickness of the mass and by weather conditions. The temperature finally dropped to about 45°F which approximates the mean annual temperature of the region. The decision was made, however, to utilize the dam by filling to somewhat less than the maximum storage level before complete cooling had occurred and before the vertical contraction joints were grouted. For tightness at the joints,

reliance was placed on the water stops. Before the second storage season, these joints will be pressure grouted in sequence from the bottom to the top of the dam. The major objective of this is to secure the designed stress distribution rather than watertightness at the joints.

Acknowledgments

The Union River Dam was designed and the construction was supervised by John W. Cunningham & Assoc. of Portland, Ore. Advice on design problems was given by Verne Gongwer of Los Angeles and overall field supervision, particularly of the grouting, was done by Richard E. Wolff of Seattle. Construction contractors were the General Construction Co. of Seattle.

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Watershed Research in Portland, Ore.

Nedavia Bethlahmy and H. Kenneth Anderson

A contribution to the Journal by Nedavia Bethlahmy, Forester, Pacific Northwest Forest and Range Experiment Station, US Forest Service, Portland, Ore., and H. Kenneth Anderson, Chief Engr., Bureau of Water Works, Portland, Ore.

MUNICIPAL governments are prone to think of water supply in terms of reservoirs, pipelines, and pumping stations. All too often, the ultimate source of the water is forgotten or neglected in the belief that good water will always issue forth from the hills and forests. The basic premises have been that the engineering phases of water supply are a continuing responsibility of city officials, but that nothing should be done about the source of water because land use problems are not the concern of the city government.

No one will question the validity of the first premise, but should the second one remain unchallenged? If forest fires affect the water supply, should city officials be unconcerned? If overgrazing induces erosion, should the problem remain unsolved? And what of the accumulating evidence indicating that vegetation covering watersheds can be manipulated to the benefit of water users? Should these reports be relegated to the files, or should water authorities take an active interest in all activities which may possibly affect water supply?

The city of Portland believes that the problem of water supply begins in the watershed, and not in the reservoir alone. In furtherance of this belief, Portland signed a contract with the US Forest Service in 1955 whereby the two would cooperate in planned watershed experiments which may ultimately benefit both the city and the federal government. This is believed to be the first time a municipal government has undertaken watershed research in the firm belief that this course of action is both necessary and advantageous.

Watershed History

The city of Portland derives its water from the Bull Run River, a small river heading in the western slopes of the Cascade Range. This river was selected after some controversy. In 1887, after the city had purchased the holdings of the privately owned Portland Water Company, the water committee hired Isaac W. Smith to seek and recommend an appropriate source of water. Smith recommended the Bull Run River, and a storm of protest ensued. Opponents claimed that the river originated in the glaciers of Mount Hood, and was therefore unsuitable as a source for public water. The controversy finally ended 4 years later when Frank Dodge, then superintendent of the water bureau, proved conclusively that the Bull Run River did not originate in the glaciers of Mount Hood. He showed that a prominent ridge separated the Bull Run watershed from Mount Hood, and that consequently

its waters resulted from local precipitation over the watershed. The Bull Run River was then approved as a source for Portland's water supply, and engineering activities were undertaken to pipe the water to the city. Four years later, in 1895, Portland had its first taste of Bull Run water.

As soon as Portland decided to draw water from the Bull Run River, legal steps were taken to protect the watershed. In 1892, President Harrison created the Bull Run Reserve; and 6 years later federal laws were promulgated concerning trespass and grazing. The law prohibits trespass to all persons except municipal and federal employees whose duties require their presence in the area, and it strictly eliminates all grazing. Furthermore, the law was given sharp teeth by a provision for severe penalties. Since the original creation of the reserve, several administrative changes have occurred, but since 1924, the watershed has been administered as part of the Mount Hood National Forest.

For many years, the only reservoir in the watershed was a natural lake located deep in the interior of the drainage (Fig. 1). This body of water was formed thousands of years ago by the action of mountain glaciers which simultaneously scoured deeply and sealed with glacial debris the porous volcanic rock barrier across the canyon of the Bull Run River. In 1920, Portland attempted to increase the storage

Fig. 1. Bull Run Lake

Located deep in the interior of the Bull Run Reserve, this reservoir has a capacity of 3 bil gal. Water from Mount Hood, in the background, does not drain into this watershed.

of the lake by a more effective sealing of the lava barrier. The engineering operation was not entirely successful, but the capacity of Bull Run Lake was raised to approximately 3 bil gal. At present, the city is building a road to this inaccessible body of water, so that modern engineering methods can be employed to convert it into a more effective storage reservoir.

As the city of Portland grew in population, additional water storage had to be provided. The problem was solved in 1929 when a 200-ft high dam was built across the Bull Run canyon some 5 miles above the headworks, thereby creating a reservoir with a storage capacity of 9 bil gal. But as a growing metropolis, Portland soon required additional water storage capacity. The city satisfied this need in 1955 by installing 8-ft vertical-lift gates across the spillway of the dam. The gates increased the reservoir's capacity by an additional billion gallons.

Portland has not stopped growing, and its storage facilities must keep up with its expanding needs. The site for another storage reservoir is now being prepared, and plans are being made for construction of the dam within the next few years.

Watershed Characteristics

The Bull Run watershed occupies 102 sq miles of steep terrain on the western slopes of the Cascade Range. Elevations range from 748 ft to a maximum of 5,100 ft. Very roughly triangular in shape, the watershed is 17 miles long and 10 miles wide.

Geologically, the area is underlain by a series of young volcanic rocks, which are both fissured and porous. One of the rock formations may be a trouble maker, because it has an inherent characteristic of becoming slick when wet; landslides occur when the proper combination of moisture and overburden conditions prevail. Such landslides can be both costly and dangerous. A recent slide ripped out a large section of the main city water conduit.

The Bull Run watershed supports a magnificent stand of virgin timber consisting mainly of Douglas fir. These trees, 400–500 years old, have long ago reached their age of maturity, and in the best interest of forest management should have been logged decades ago. Many of these large trees are dying because of their advanced age, and so contribute to the fire hazard potential. Douglas fir is normally associated with hemlock and several other species. The young hemlock seedlings tolerate the forest shade much more effectively than Douglas fir, and therefore, barring fires, a mature Douglas fir forest will gradually be transformed into a hemlock forest. Such is the case in the Bull Run watershed; in many areas the Douglas fir forest has given way to hemlock and other tree species. Light insect infestations have occurred in recent years, and these too have taken their toll. Notwithstanding all these depredations, the timber volume in the watershed is very high; the best estimate places it at 3.6 billion fbm.

Continuous long-time precipitation and runoff records are available only for the lowest part of the watershed, but some data have been taken at the higher altitudes. On the basis of all available information, and considering the topography and elevation of the watershed as a whole, the average annual precipitation is about 123 in., whereas runoff is 99 in. Thus, approximately one-fifth of the annual precipitation cannot be recovered. Because of melting snow, runoff during

May usually exceeds precipitation. This phenomenon may also characterize the months of April and June. Runoff is at a minimum during the 4 months July–October.

The quality of Bull Run water is excellent; only chlorination is required to prepare it for public consumption. Half a century ago the USGS analyzed the water, and found only a trace of suspended matter and a mere 30 ppm of dissolved solids. Today, this analysis still holds true. In other words, ever since the watershed was selected as a source of water, its influence on quality has remained stable.

Years ago the watershed was completely inaccessible. Roads and trails were scarce, and the federal laws forbidding trespass were easily enforced. Now, civilization is encroaching from all directions: logging operations are being performed in close proximity; power lines cross the tip of the watershed; the population of nearby communities is increasing; and larger numbers of people are seeking outdoor recreation opportunities. Roads and trails in the watershed are still scarce, and are a deterrent to trespass; but their scarcity also hinders good forest administration, particularly with respect to fire control.

Watershed Problems

Superficially, the Bull Run watershed presents no problems. Here is a watershed which for half a century has supplied the city of Portland with an adequate amount of good water; and with the construction of adequate storage facilities, it could provide enough water far into the foreseeable future. But problems do exist, and some of them are urgent and demand early solutions.

The problem of fire control has already been mentioned. Thus far, catastrophic fires have not occurred. But the probability of occurrence of man-caused fires is increasing, and they may have far-reaching effects on the quality of water yielded by the watershed. If a catastrophic fire were to lay bare a portion of the watershed, what could be done to revegetate quickly the denuded areas? What plants should be used, and which techniques are the most effective? This type of problem has received wide publicity by the man-made California fires of late 1956.

A closely related problem deals with the soil mantle. All soils are not equally subject to erosion; some erode easily, while others are more resistant. The problem, then, is to determine in advance the potential sediment-producing areas, so that in case of fire they will receive prompt attention.

A large portion of the yearly precipitation occurs as snow, and a great deal of this snow is intercepted by tree crowns and evaporated back into the air. What can be done to catch more of the falling snow? Studies in Colorado, California, Michigan, and elsewhere have shown that substantial increases in the amount of snow accumulated on the ground can be effected by cutting openings in the forest and that the efficacy of this procedure depends on the size of the openings with respect to the height of the surrounding trees and their alinement with respect to the cardinal points.

What can be done to increase stream flow? Again, studies in Colorado, North Carolina, and elsewhere have shown that the removal of timber increases runoff. But if ordinary logging procedures are followed, detrimental erosion and siltation may follow. It is necessary to devise logging procedures that minimize soil disturbance

before the conflict between timber and water values of a watershed can be resolved.

Low summer flows prevail in the Bull Run River. Can these flows be increased? Studies in North Carolina have shown that the removal of riparian vegetation increases summer flows by a substantial amount. Can this method be used in emergencies, when a drought occurs? And what can be done to prevent excessive evaporation from reservoirs? Studies in Texas and Australia have shown that economic savings are feasible.

Research Program

All of the problems discussed above require specific answers. Basic solutions may be universal but still different in their specific application to particular circumstances. The Douglas fir forest of the Bull Run watershed differs from the Colorado lodgepole pine forests and the Carolina hardwood forests, and the specific solution to the watershed's problems can be ascertained only by intensive local experimentation.

The fact has already been mentioned that the city of Portland and the US Forest Service signed a 20-year contract whereby the two would cooperate in performing experiments on the Bull Run watershed. The first phase of the experimental work was started in 1956. Three small watersheds within the Bull Run area were selected for study and appropriate gages were installed in one. Two additional gages remain to be installed. The three watersheds will be calibrated over a period of years to determine the precise relationship between undisturbed timber cover and stream flow. Then one will be logged in accordance with the best methods known. Snow openings will be made in the second, while the third watershed will remain untreated and serve as a check.

Additional problems will be attacked according to a set priority as soon as installations have been completed on the three subwatersheds.

The concept that good water supply depends on good land management has not been widely recognized. It is a relationship which will require more attention as the needs for usable water continue to increase. Steps now being taken by the city of Portland to meet some of its water supply problems through watershed research are indicative of this progressive approach.

Seattle's Need for Additional Water

J. Ray Heath

A paper presented on May 2, 1957, at the Pacific Northwest Section Meeting, by J. Ray Heath, Supt., Seattle Water Dept., Seattle, Wash.

SEATTLE, like practically every other community in the country, has experienced increase in growth and population which has made it necessary that additional water supply be developed to meet the needs of the community.

In 1945 the Seattle Water Department was supplying a 425,000 population in the city of Seattle, and 75,000 in adjacent water districts and communities, making a total population served at that time of 500,000. In 1955 these figures increased to 550,000 in the city and 100,000 in the communities adjacent to the city, making a total of 650,000 people. It is expected that by 1970 the total population served by the Seattle Water Department will reach 750,000.

To supply the requirements of 1945, the capacity of delivery was 130 mgd, the average demand being 74.5 mgd.

In 1955, through addition of additional supply mains and pumping facilities, the supply capacity was increased to 200 mgd, with an average demand of 187 mgd and a 1-day peak demand of 207 mgd. In 1956, the supply capacity was still 200 mgd, with an average demand of 193 mgd and a 1-day peak of 232 mgd. During this period of high demand in 1956, however, considerable water was drawn from the reservoirs, lowering the gradient, which increased the maximum delivery to 222 mgd.

In 1957, there has been and will be one additional supply main and three additional pumping stations added to the system, which will increase the available supply to 240 mgd. Obviously, it is not possible to continue adding facilities to the present system, adequate to supply future demands. Therefore, it has become necessary for the city of Seattle to commence development of another source of supply, completely independent from its present Cedar River supply. This new source is the Tolt River development, from which is expected to be delivered to the city in 1960 an additional 90 mgd, making the total available supply at that time 330 mgd. Seattle has been able adequately to supply water during the occasional hot, dry summers by virtue of the storage capacity within its system. Present storage capacity is 360 mil gal, or 565 gal per capita.

In 1958, there will be added to this amount 22 mil gal, and in 1960, with the Tolt development, an additional 60 mil gal, making a total storage capacity at that time of 444 mil gal, or 635 gal per capita, based on an estimated 750,000 population.

Rate Increase

In order to make these improvements it was necessary for the city of Seattle to increase its water rates to supply revenues to cover these capital costs.

In May 1955, the Seattle Water Department requested the city council to increase revenues, sufficient to return a 30 per cent increase in total yearly revenues. This request was approved in October 1955. Due to litigation by certain interests within the city, however, the rates were not made effective until April 1956. The right of the city council to raise rates was questioned, but the supreme court ruled that the city council can raise rates sufficiently to cover capital cost and operation and maintenance.

A year's experience with the new rates in effect shows an increase of 35.6 per cent in revenue for the entire year. Part of this increase, however, was due to the hot, dry summer in 1956.

Tolt Supply

A feasibility report on the Tolt River as a source of supply for the city was made in 1936. Prior to the planning for development of the Tolt, however, consideration was given to development of further supply from the present Cedar River source. Due to the necessity for additional supply mains through the city, however, it was found that increased development of supplies from the Cedar River source would be more costly than developing a new supply from the Tolt River. In addition, it has long been recognized by the Seattle Water Department that an additional independent supply would be desirable, thus eliminating the possibility of disruption of service through disaster caused by natural or unnatural means, such as earthquake or bomb damage.

The Tolt River supply will be delivered to the north end of Seattle, as opposed to the present supply from the south, and will be delivered 100 ft higher than the present Cedar River supply, thus eliminating much of the pumping now required to supply the northern portion of Seattle and areas adjacent to it.

During the economic studies of further development, a cost comparison was made between the development of the Cedar River supply, based on present-day costs through the *Engineering News-Record* cost index and the estimated costs for development of Tolt River supply. The Cedar River supply if developed at today's prices, would cost $484,721 per million gallons capacity. The Tolt River supply is estimated to cost $245,724 per million gallons capacity, which is slightly more than one-half of development costs for the present Cedar River supply.

In planning of the Tolt River supply very careful consideration has been given to the design and location of the impounding reservoir, and each phase of the project has been investigated by various qualified consultants. All engineering design and construction is under the supervision of water department engineers.

In 1952, an investigation and report was made by Howard W. Coombs, University of Washington geologist, Stirling Hill, retired engineer, and James Patrick, soil engineer.. The results of these investigations indicated that the dam site and conditions in the area were favorable for the construction of the proposed impounding reservoir. In 1955, a contract was entered into with consulting engineers for plans and design of the dam, and further studies of storage requirements were made.

The dam to be constructed on the south fork of the Tolt River will be an earth-filled dam with the concrete gravity section and spillway on bedrock.

The overall height will be 205 ft; length of crest, 1,000 ft; and the storage capacity, 60,000 acre-ft. The total estimated quantity of excavation earth is 400,000 cu yd; excavation rock, 100,000 cu yd; embankment earth, 200,000 cu yd; rock, 650,000 cu yd; blanket, 250,000 cu yd; impervious core, 100,000 cu yd; mass concrete, 120,000 cu yd; and reinforced concrete, 5,000 cu yd. The total estimated cost, for which an appropriation has been approved by the city council, is $7,200,000.

The south-fork development is the first stage of development in this Tolt River supply, and it is expected that by 1975 further development will be made on the north fork of the Tolt, which will increase the total available supply from this source to 180 mgd.

The present plans call for construction of unit No. 1, which is the dam on the south fork, and construction of 30 miles of pipeline in sizes of 66-in., 60-in., and 54-in. diameters, for a capacity of 90 mgd. A receiving reservoir will be constructed at the north end of Lake Forest Park at the north end of Lake Washington. This will have a capacity of 60 mil gal.

Recreational Uses

There has been a difference of opinion between the officials of the city of Seattle and the state game and fisheries departments of Washington in regard to the use of the Tolt watershed area for hunting and fishing.* It is the contention of the Seattle Water Department that since both points of diversion in the forks of the Tolt River are above natural-barrier waterfalls, each of which have a height of from 70 to 85 ft, that no interference to fish life will be caused by the diversion of this water or the restriction of fishing in the stream above the intakes, since it would be necessary for the state game department to plant fish above these barriers.

The construction of the dam will be beneficial to the propagation of fish, due to the fact that the water department has entered into an agreement to augment the natural stream flows in order that a flow of 200 cfs may be maintained from September 15 to June 1 and that a minimum flow of 125 cfs be maintained from June 1 to September 15 each year. During critical years, however, these amounts may be reduced by 30 per cent if that amount of water is required for domestic consumption. The assurance of these flows will greatly benefit the propagation of fish in the lower portions of the Tolt River and will prevent disastrous loss of fish, which has occurred during extremely dry years. It is the intent of the water department to operate the Tolt River watershed on the same basis as that of the Cedar River, which has proved extremely successful throughout the past 60 years.

Costs for treatment which would be required if the watersheds were open to multiple use are as follows: Cost of construction of treatment plant would be $100,000 per million gallons daily capacity. On the Tolt River development a 15-mgd treatment plant would cost $15,000,000. Operation of such a plant would be $15 per million gallons per day, amounting to $750 per day, or $273,750 per year. Depreciation of the plant on the 50-year basis

* Since this article was written, a bill was introduced in the Washington legislature which would have permitted the opening of all watersheds of more than 200 acres, municipally owned or otherwise, to access for hunting and fishing. The bill was killed in committee, largely through the efforts of water department officials, but it is expected that similar legislation will be introduced in 1959.

would be $300,000 per year, making a total cost of $573,750 per year of operation.

If this area is needed for recreation in 25 years, then a treatment plant could be constructed. To construct a plant now, which is not needed for 25 years or more, however, would cost the city of Seattle about $23,238,750 in the 25-yr period. This figure is based on a construction cost of $15,000,000, with 3 per cent interest compounded annually ($16,395,000) and $6,843,750 for operation and maintenance. The total of $23,238,750 for the 25-year period is $929,550 per year. The interest is only on improvement, operation, and maintenance, and does not include a depreciation figure. These costs are excessive and are not justified to permit a special privilege to hunters and fishermen.

With the complete development of the Tolt River supply and further development of the Cedar River to furnish at least another 100 mgd, Seattle will have sufficient water for a population of 1,750,000. Construction of these facilities will be scheduled to meet demands as they develop.

Water and Sewage Facilities for the Kansas Turnpike

P. Clifford Sharp

A paper presented on Apr. 10, 1957, at the Kansas Section Meeting, Wichita, Kan., by P. Clifford Sharp, Partner, Haskins, Riddle & Sharp, Cons. Engrs., Kansas City, Mo.

FOR the most part, the problems encountered in turnpike construction are very similar to those commonly encountered in normal highway programs, and comprehensive records are readily available for guidance. Similarly, the planning and construction methods are well developed for highways, as well as adjacent accommodations, such as trailer camps (*1*). But a turnpike has some features which cause it to vary quite widely from a normal highway project.

One feature of course is the method of financing. Another feature is the provision of service areas adjacent to the turnpike. These service areas provide eating and automobile service facilities for use by the turnpike patrons. With such facilities there naturally are involved such utilities as water, light, heat, air conditioning, and sewage.

Although some turnpikes have been in operation for several years, the factual data that are available with reference to water consumption, sewage flow, strength, and composition, leave much to be desired. This was soon discovered by the author's firm when it was employed to design the water supply and sanitary sewerage facilities for the service areas on the Kentucky and Kansas turnpikes.

A search was begun for factual data that would provide a reliable basis for design. Data on the amount of water purchased by various service areas on the Pennsylvania and New Jersey turnpikes were not difficult to obtain, since most of them purchased water from public utilities and the meter readings were readily available. The relationship, however, between the water used and the number of people served or traffic count was not so easily determined.

Water Requirements

Personal inspections of a number of service area installations on the Pennsylvania and New Jersey turnpikes yielded pertinent data, which was supplemented by information from the restaurant people. The data thus obtained were compiled and studied, and the following conclusions reached concerning water requirements:

1. Ten per cent of the cars passing a given service area would be customers of that service area.
2. The average number of people per car would be three.
3. Data from the Valley Forge, Pa., service area indicated a minimum water use of 15 gal per restaurant customer with an average restaurant check of 72 cents per customer. On some holiday weekends the use increased to 20 gal per customer and an average check of 87 cents.

4. Restaurant operators suggested a design basis of 350 gpd per counter seat and 150 gpd per table seat. These values, applied to the Valley Forge installation, gave daily flows agreeing quite closely with, but being slightly higher than, the observed maximum water usage.

5. The water use per customer is higher in warm months than in cool months.

6. From the traffic standpoint, the peak month can be expected to be 150 per cent of the annual average, but the peak month for food sales will be about 162 per cent of the annual average. The water consumption follows food sales very closely.

With the above conclusions in mind, it was determined in planning the Kansas Turnpike that:

1. Design capacity would be 45,000 gpd for the major service areas (Lawrence, Emporia and El Dorado) and 25,000 gpd for the minor service areas (Wellington, Matfield Green, and Topeka).

2. Existing public supplies would be utilized as a source if at all possible.

3. If new supplies had to be developed, ground water resources were preferable to surface sources.

4. New supplies would require treatment facilities, the type and extent of which would be governed by the quality of the raw water.

5. Economic considerations coupled with reliability of service and location of the service areas, made it desirable to provide 40,000 gal of elevated storage at each service area.

6. If possible, supply wells would be located on the turnpike right of way.

7. The number and size of wells to be constructed would be determined after test wells had been constructed and tested.

8. The treatment facilities would be based upon the results of chemical and bacteriological tests made upon samples secured from the test wells.

Preliminary surveys were made which showed that only the Topeka service area could be served by an existing public water supply, the other five service areas requiring their own sources of supply. Accordingly, plans and specifications were prepared.

Fig. 1. Service Area, Kansas Turnpike

Construction Details

Plans called for test wells to be constructed for the purpose of securing detail data upon which to base permanent well construction. Gravel wall wells were contemplated for the Wellington and Emporia service areas; and drilled and cased wells for the El Dorado, Matfield Green, and Lawrence service areas, with the stipulation that acid treatment was to be provided, if deemed necessary, for the El Dorado and Matfield Green wells. Further, it was specified that each well would be provided with a submersible pump dis-

charging through an approved type of underground frostproof, pitless, sanitary discharge connection.

Bids were received and a contract awarded. Then started the scramble for water. Since the service areas had been located according to distances and driving times, this resulted in sites where ground water in any appreciable amounts was practically nonexistent, and surface water hadn't been seen since 1951. Eventually, however, water was found in amounts sufficient for the anticipated needs.

Wellington was supplied by two gravel wall wells located north of the Ninnescah River; Elorado by three drilled and cased wells located west of the Whitewater River; Matfield Green by two natural gravel wall wells located 3.7 miles northeast of the service area in Thurman Creek valley; Emporia by two gravel wall wells located 1.5 miles southwest of the service area; and Lawrence by four drilled and cased wells located about 1 mile west of the service area.

The chemical quality of the various waters was such as to result in the following treatment facilities:

At El Dorado, Emporia, and Lawrence, well water, pumped to a forced-draft aerator, is chlorinated as it enters a covered settling basin located beneath the aerator and pumped through a pressure filter and cation-exchange softener into an elevated tank, such as the one seen in Fig. 1. Pressure controls located in the base of the elevated tanks actuate the 50-gpm high-service pumps, which operate on alternate cycles. These pumps take suction from the settling basin which has a total 5-hr capacity, 2 hr of which is reserved for sludge capacity. Water level controls located in the treatment buildings actuate the desired well pumps, hypochlorinators, and aerator fans.

The softeners were sized to provide 102-ppm finished water and were specified to be of the automatic regenerating type. The spent brine is discharged to a concrete pit, from which it is pumped to the service area sanitary-sewer systems, in order that it will be sufficiently diluted prior to being released into the receiving watercourse. The pressure filters are backwashed manually, backwash water being secured from the elevated tanks.

At Matfield Green and Wellington, the water is chlorinated as it is pumped to the elevated tank. Chlorination is automatically and proportionately achieved by means of hypochlorinators. Pressure controls in the base of elevated tanks actuate the well pumps. The supplies to the hot-water systems in the restaurant buildings are softened by cation-exchange softeners located in the basement.

At Topeka the water is supplied directly from the city's distribution system.

It is of interest to note that the fans on the forced-draft aerators provide 1.67 cu ft of air per gallon of water. The filtering rate is 2.54 gpm per square foot of surface area. The control signal is conveyed from the elevated tank to the treatment plant by means of buried cable in all cases, and from the treatment plant to the wells at Emporia and Lawrence. But, at El Dorado the signal from the plant to the wells is sent by means of two-tone, sequenced radio transmitters at 27.255 megacycles. The radio signal system was also used between the elevated tanks and the wells at Wellington and Matfield Green. The radio systems were used where long distances or river crossings were involved.

Sewage Requirements

While the water phase of the projects was being processed, work on the sewerage phase was also underway. The search for factual data showed that practically all of the available data had been secured by manufacturers producing sewage treatment equipment. This was obtained and studied, and in addition there were personal inspections of a number of installations on the Pennsylvania and New Jersey turnpikes to observe the types of facilities provided, their condition, and treatment efficiencies.

The data thus obtained were compiled and studied, and the following conclusions were reached:

1. The sewage flow from a turnpike service area will fluctuate rapidly and widely, generally hitting a maximum peak of approximately 200 per cent of the average daily rate during the noon hour and a secondary peak of about 160 per cent of the average around 6 PM. In addition to the daily variations there are seasonal variations and some unexplainable, nonseasonable variations at various service areas.

2. The sewage from service areas consists predominately of restaurant wastes; the rest-room wastes are less in quantity and strength, low in solids content, and high in soap and urine. The sewage received from a service area can be expected to have approximately the following composition: BOD, 600 ppm; suspended solids, 300–450 ppm, of which about 90 per cent is volatile matter; pH, 9.5; grease, 100 ppm; active detergents, 100 ppm; and temperature, 70–85°F, with a maximum of 130°F.

3. The sewage treatment facilities should be simple to operate and maintain, capable of handling wide variations in hydraulic loading, and rugged enough to handle extreme change in organic loading. The simplicity of operation and maintenance cannot be overemphasized, since the turnpike authorities commonly use a crew of one or two men to operate the water and sewage facilities for two or more service areas.

After the data were compiled, a conference was held with the Kansas State Board of Health at Lawrence. The result of this conference was criteria to govern sewage treatment facilities for the service areas on the Kansas Turnpike, as follows:

1. Recirculation rate of not less than 1 : 1 must be provided, and settling facilities sized accordingly.

2. Imhoff tanks were acceptable, provided the overflow rate did not exceed 1,000 gpd per square foot and sludge digestion capacity was not less than 6 cu ft per capita.

3. Trickling filters could be loaded up to 650 lb of 5-day BOD per acre-ft.

4. Final clarifiers must have an overflow rate of not to exceed 1,000 gpd per square foot, based on maximum rate of raw-sewage flow. Also, continuous removal of sludge should be provided.

5. Sand filters should have sand with an effective size of between 0.5 and 0.75 mm. Open filters could be loaded up to 80,000 gpd per acre and covered filters up to 10,000 gpd per acre.

With the above data in mind, the design criteria were established. Since nearly all the available data related to water usage, it was decided to design the sewage treatment facilities on the basis of receiving a raw sewage flow equal to the water usage. Thus, any water used for car washing, lawn sprinkling, or other similar non-contributing purposes would provide that much of an additional safety factor.

No waste water from car washing and greasing operations would be discharged to the sanitary sewer system.

The sewage treatment plants would consist of: a comminutor; Imhoff tank; constant-rate, standard-type, trickling filter; a final clarifier with mechanical sludge removal; recirculation facilities; and facilities to permit of loading wet sludge for disposal in the liquid state. This type was selected because it could be so arranged as to be compact in layout, was of dependable performance, and was simple to operate and maintain. Further, since none of the plants would discharge into any appreciable receiving stream, it was necessary for the plant to produce continuously a high-quality, well stabilized effluent. Activated sludge was ruled out because of operational difficulties experienced elsewhere. Sand filters were similarly decided against because they had failed at previous turnpike installations. The main reason for failure was due to plugging with grease carried through the primary clarification units by the detergents used in the restaurant operations.

In order that land acquisition could be held to a minimum, the plants would be constructed within the service area, between the separated turnpike lanes, and as far removed from the restaurant facilities as feasible.

The waste lines from those kitchen operations that could normally be expected to contribute grease would be discharged into a three-compartment, 500-gal capacity grease trap of concrete construction and having ready access for grease skimming.

Study of the expected traffic flow and consequent patronage indicated that the three major service areas (Lawrence, Emporia, and El Dorado) could be made identical, each to receive a raw-sewage flow of 40,000 gpd from an equivalent population of 1,200 persons.

Flow Pattern

Raw sewage flows to the plant by gravity and passes through a comminutor into an open wet well located immediately beneath. Vertical centrifugal sewage pumps located in an adjacent dry pit lift the sewage to the Imhoff tank at a constant rate continuously. The tank effluent flows by gravity to the rotary distributor on the trickling filter, and the filter effluent flows by gravity to the final clarifier. Final clarifier effluent flows through a sump and on to the receiving drainage course. A flow, sufficient to make up the difference between the pump capacity and the raw-sewage flow, is automatically returned by hydrostatic head from the sludge hopper of the final clarifier to the wet well. The trickling filter may be bypassed, the final clarifier may be bypassed, or the entire plant may be bypassed. In the event of a power failure, raw sewage automatically overflows a weir and passes through the final clarifier prior to entering the receiving drainage course. Water for scrubbing and lawn-sprinkling purposes is secured by means of a pump located in the sump situated in the effluent lines from the final clarifier. A loading platform, equipped with a hose connection, is provided for the loading of liquid sludge by hydrostatic head directly from the Imhoff tank into a sludge-hauling tank. The loading platform drains by gravity into the plant influent.

One feature, not often used, was incorporated into the plant design at the suggestion of the state Board of Health. This feature consists of a time

clock-controlled blower to introduce air below the liquid level in the gas vents of the Imhoff tank for the purpose of keeping the scum broken up.

The treatment plants for the three minor service areas (Topeka, Matfield Green, and Wellington) are also identical, each to receive a raw sewage flow of 25,000 gpd from an equivalent population of 750 persons. The layout and flow pattern of these plants is the same as for the major service areas.

Costs

The costs for the individual plants naturally varied somewhat due to individual plant factors. Those for the major area plants averaged $57, and those for the minor plants averaged $82.60 per capita of equivalent population. These are a little high due to the fact that the power cable from the restaurant building to the treatment plant was included in the lump sum bid for the plant.

The cost of the three water treatment plants varied from $422 to $442 per 1,000 gpd of net capacity, and averaged $432.50.

The amounts of the various contracts covering the water and sewerage projects were as follows:

Item	Cost
Water wells	$ 41,031
Elevated tanks	191,980
Water treatment and transmission facilities	371,987
Subtotal	604,998
Sewage treatment and facilities	478,018
Total	$1,083,016

The desirability of securing factual data from operating turnpike facilities should again be emphasized. Such data should include the traffic count, food sales, water consumption, and sewage flow and composition. Also, the importance of competent operating personnel cannot be overemphasized, as has been confirmed by some of the problems encountered to date.

Reference

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Use of Radial Collector Well in Skagit County, Wash.

Robert A. Yale

A paper presented on May 3, 1957, at the Pacific Northwest Section Meeting, Tacoma, Wash., by Robert A. Yale, Engr., Public Utility Dist. No. 1 of Skagit County, Mount Vernon, Wash.

THE Public Utility District No. 1 of Skagit County, Wash., owns and operates the water systems of the cities of Mount Vernon, Burlington, and Sedro-Woolley, and also much of the rural area between and around these centers. All of these systems are interconnected by main transmission pipelines so that single or multiple water supplies can service all of the service areas.

Skagit County is fortunate in having available all three basic types of water supplies, using all of them in various stages of development. The district maintains and operates an old filtration plant in Mount Vernon to purify and clean the turbid water of the Skagit River. It has long operated a partially developed, distant, mountain gravity system that is at present disconnected from the distribution plant due to the repeated failure of a connecting underriver pipeline. Also, three vertical wells are in service at various locations in the water systems. To increase water supplies it is necessary for the district to consider the economics of developing and operating each type of source. Late studies have indicated that when the total peak water demands exceed approximately 8.0 mgd, the most feasible supply to develop would be the distant gravity system, unless a ground water supply requiring a minimum of treatment could be located near the main load centers.

For several years the district has explored the ground water possibilities in the Skagit Valley. The possibility of inducing Skagit River water into underground aquifers by means of pumping from vertical wells was investigated. Due to the relatively small area of influence of a vertical well and the inability to direct this influence toward the main water body, such inducement appeared to be negligible. All the ground water studies showed that ample quantities of water could be made available at several locations, but all would require treatment for iron removal and, at times, other mineral reduction.

Investigations of ground water supplies indicated a possible use of radial collector wells to infiltrate water from the Skagit River. In the spring of 1954 geologists were employed to perform hydrogeological surveys near Mount Vernon in an area of promising aquifers to determine the feasibility of a collector well for Skagit County. Two sites were studied. The first promised up to 15 mgd firm supply, but the water produced would require treatment to remove a high amount of iron. The second site indicated an available minimum supply of about 5.0 mgd at an acceptable quality. A col-

lector well * was constructed at this second site and placed into operation in August 1954.

Construction of Well

The Skagit collector well consists of a vertical caisson with an inside diameter of 13 ft. The caisson walls are of reinforced concrete 18 in. thick and the overall depth is 53 ft. The caisson extends 40 ft below ground and 13 ft above ground. The top is elevated so as to be higher than the nearby river dikes to afford maximum flood protection to the vertical-turbine, deep well pump motors. These motors and controls are housed in the pump building constructed on top of the caisson. The bottom of the caisson is plugged with a concrete mass. At a level 18–24 in. above the caisson floor, eight 8-in. diameter, perforated-steel, lateral collectors extend outward into the aquifer. Seven of these laterals are laid out in a fan-shaped pattern in a direction toward the river. The three center laterals heading most directly to the river are each 40 ft long, and the longest lateral, running nearly parallel with the river, is 120 ft long. The eighth lateral extends 76 ft from the caisson directly away from the river. This lateral has a special purpose as a quality controller. The total projected length of perforated laterals is 532 ft.

On the end of each lateral inside the caisson a 10-in. gate valve is connected with valve stem extensions to the pump room operating floor so that each of the laterals may be shut off to facilitate the dewatering of the caisson. Three deep-well, vertical-turbine pumps are installed in the collector with a total pumping capacity of 4,200 gpm.

* The well was installed by Ranney Method Water Supplies, Inc., Columbus, Ohio.

The district has had over 2½ years of experience with the collector well. Outside of three Boise, Idaho, wells, it is the oldest collector well in domestic water supply service in the Pacific States. Generally, the operation of the collector has been satisfactory, though the resultant water quality has not come up to the standard expected. The iron content of the water has seldom dropped below 0.5 ppm, remaining the majority of the time in the range of 1.0–1.5 ppm. The pH remains at about 6.8, and the carbonate hardness varies between 18–30 ppm. The normal ground water in the vicinity of the collector has an iron content of from 4.0 to 6.0 ppm. Any iron within the river water is oxidized, and becomes filtered out along with other suspended matter as that water infiltrates into the collector.

Since as little of the ground water as possible was desired in the collector and the major portion was to be infiltrated from the river, the seven main laterals were projected in the direction of the river. It would have been possible to project the laterals further outward under the river bed to increase further the proportionate amount of river infiltration, except for the possibility of the river flow scouring too much material off the river bottom and reducing the thickness and effect of the river bed filter media or possibly even exposing the laterals. The laterals and caisson could go no deeper because of an underlying clay stratum.

The direction of the collecting laterals causes the gradient of the water table to be much steeper on the river side of the collector than on the landward side, which, in turn, induces a much higher percentage of the total amount of water produced from the river than from the landward ground.

To cause the landward water table gradient to be even less steep, one lateral was installed projecting from the caisson away from the river. This lateral is connected directly to a small turbine pump of 300-gpm capacity which discharges to waste. Effectively then, this lateral and pump are intercepting some of the ground water of high iron content before it can flow to the main laterals. In order to maintain the water table gradients at their relative slopes, it is necessary to pump from the collector at all times.

Several factors other than pumping, however, affect these slopes. One is the varying levels of the river water surface, and another is the amount of recharge to the ground water from rain and snow melt, which affects the ground water table. Another very important factor is the relative temperature of the river and ground waters, varying the viscosity of the water, which greatly affects the transmissibility of the water through the aquifer.

Water Quality

In February 1955 the collector water iron content began to climb from an average of 0.8 ppm to 1.5 ppm with the same continuous pumping rates. This was a period of much rainfall in the lowlands, thereby raising the ground water table several feet. The river level did not rise appreciably, since this water originates primarily from the higher snow fields. Further, the river water was very cool, increasing its viscosity and thereby reducing its transmissibility to the collector. Rather than increase the collector pumping rate and wasting water to make the river water gradient steeper in relation to the ground water gradient, a pump was installed in an old 18-in. abandoned well located about 300 ft landward from the collector. About 550 gpm was pumped from this well to waste. Within 7 days after starting this pump the iron content dropped from the high of 1.5 ppm to 0.7 ppm, while all other conditions remained nearly constant. This well has been used continuously since this time as a quality controller.

As long as the iron content could be kept below 0.8 ppm, there were no complaints, and pipe blowoffs indicated the absence of red water in the distribution systems. During the past 2 years, however, the iron content has more often been above 1.0 ppm, and shortly over a year ago facilities were installed and placed into service to feed sodium hexametaphosphate to the water to stabilize the iron and prevent its oxidation. Complaints of red water are very few, and staining is held at a minimum with the use of this chemical.

Although the quality of water from this well is not as good as was expected initially, it nevertheless has proved to be a relatively economical plant to operate. For example, during January, February, and March of 1957 the cost of pumping, chemical treatment, and labor to operate this plant amounted to slightly less than $16 per million gallons of water produced.

The primary reason for the difference in water quality from that which was initially calculated in the hydrogeological survey information was misinformation obtained in regard to river water temperature and the normal ground water quality. Also, usually 90 per cent of the total water produced in a collector is infiltrated from the nearby surface source, the river, and the remaining 10 per cent comes from the surrounding ground water reservoirs. In this case, however, from 20 to 35 per cent of the total pro-

duced water is from the landward ground water. This is because of the fairly coarse open landward aquifer in the area of this collector well compared to the aquifer toward the river.

Performance Results

Ever since this well was first placed into operation, regular measurements have been taken and recorded of the water table levels, river levels, water temperatures, pumping rates, production, and waste water qualities. Using these measurements it is possible to check regularly the performance of the well. In November 1956 a study was performed to determine if there had been any appreciable change in the production capacity of the collector well. The results of the study showed that the capacity has remained uniform since the first pumping.

The Skagit Public Utility District has had a successful experience with its radial collector well, which has proved to be a vital link in the water production developments in Skagit County. Ground water explorations, however, up and down the Skagit Valley near the major service areas, do not indicate another possible site for more collector installations to produce water that would not have to be completely treated for iron removal. No sites are evident that would produce water as good as that from the existing well. Therefore, it has become most feasible to return to the distant gravity system for further supply developments. The existing collector well will always plays an important role as a peaking and standby facility, a vital part of a system consisting of long transmission lines and unusually variable load demands.

Service Rules and Standards for California Water Utilities

William C. Welmon

A contribution to the Journal by William C. Welmon, Secy.-Treas., Southern California Water Co., Los Angeles, Calif.

ON Jul. 18, 1955, the California Public Utilities Commission issued an order instituting an investigation to consider the adoption of service standards and service rules for water utilities under its jurisdiction. The adoption of rules and standards is a matter of great concern not only to water utilities of California, both private and public, but to all water utilities throughout the country. As the water industry on a national scale watches with great interest developments in other states, any standards adopted and authorized by the California Public Utilities Commission would undoubtedly be a pattern for regulatory bodies in other states. Because of this fact, the headquarters office of the American Water Works Association evidenced an interest in the proposed proceedings, and L. J. Alexander, then chairman of the California Section of the AWWA, appointed a committee to represent the California Section in this matter. A committee was appointed from the Water and Sewage Works Manufacturers Association to act as advisors and consultants to the committee on service standards and rules.

Hearings were held by the California Public Utilities Commission in San Francisco on Aug. 31, and in Los Angeles on Sep. 7, 1955. Some of the important points of interest that occurred at the hearings were:

1. The sources of material for the commission's proposed rules and standards were, for the most part: the proposed rules and standards of the National Association of Railroad and Utilities Commissioners (NARUC); the "Standards of Minimum Requirements for Delivery of Water for Domestic Use," adopted by the California Section of the AWWA on Oct. 29, 1948; and the "Tentative Regulations Governing Water Service," accepted by the California Section of the AWWA on Oct. 27, 1950.

2. Present rules regulate the utilities' relations with customers. The proposed rules would regulate the utilities' relations with the commission, although some sections pertain to relations with the customers. It is not the intention to bypass the presently filed rules and regulations; duplications may occur, however, and the new rules and standards, if adopted, should prevail, and the utility should file new rules to eliminate any conflict.

3. It is not intended to make any utility bring its water system up to the proposed standards if the existing system does not now meet them. The proposed standards affect new construction only.

4. Service standards and service rules would be promulgated for water utilities in California.

5. At these hearings the commission was advised that the California Section of the AWWA had appointed a committee for the purpose of working on service standards and service rules. Pursuant to the request of certain of the appearances at the Aug. 31, 1955 hearing in San Francisco, the commission allowed the committee of the California Section until Mar. 31, 1956, to complete and send to the commission its proposals for service standards and rules. It was suggested that prior to the filing of the committee's proposals it would be desirable for the committee to review thoroughly all proposals with the staff of the commission.

Committee Operation

The committee of the California Section consisted of 36 extremely capable and experienced men from small utilities as well as large utilities, and from municipal as well as private water companies. These members represented more than 600 years of experience in the water utility business. The committee was divided into three general groups as follows: rules and regulations; engineering and construction (including sanitation and public health, engineering design and construction, and materials and specifications); and meters and metering.

A preliminary meeting of the committee was held on Aug. 30, and an organization meeting on Sep. 7, 1955. The committee members did not take their task lightly, and they worked diligently on the preparation of proposed standards from the time of the Sep. 7, 1955, hearing of the commission. The engineering staffs of certain of the companies have worked to test various points in the standards, and contact has been made with various manufacturers to determine that all points of interest or conflict in the proposed standards would be considered. Individual members worked singly and together on their portion of the standards and the chairman of each group correlated the work of his members for presentation at each of the three group meetings held late in November 1955.

A meeting of the committee of the Water and Sewage Works Manufacturers Association was held on Jan. 10, 1956, to discuss certain portions of the standards in which they were most vitally interested. Those sections pertained to portions of engineering and design and meters and metering.

A general committee meeting was held on Jan. 11–12, 1956, when agreement was reached on the proposed service standards and rules to be presented to the staff of the commission for discussion.

After discussion among the committee members, it was decided to retain an attorney to assist in the discussions with the staff of the commission. None of the members questioned the need of standards. All agreed with the objectives of the commission, but not with the standards as originally proposed.

The committee, represented by the general chairman and the chairman of the subcommittees, had a preliminary meeting with the staff of the commission on Mar. 1, 1956, for the purpose of explaining to the staff the initial suggestions of the committee. Subsequently, several meetings were held in March 1956 for the purpose of discussing the nature and extent of the revisions needed. Fine cooperation and consideration was given to the committee by the commission's staff members at meetings.

In formulating service rules and standards, there are many regulatory and operating problems to be consid-

ered. The nature of these problems can best be fully understood when an opportunity is afforded to the operators and commission staff to discuss in detail their various problems with each other. The most important step in the preparation of proposals for rules and standards was when the representatives of the committee and the staff of the commission sat down around a table to discuss their problems. The discussions were conducted in a constructive manner. The committee was undoubtedly unaware of some of the regulatory problems that the staff members had to consider in the preparation of its proposed standards, and the commission staff likewise was not familiar with some of the operating problems that the standards would pose to the operation of a water utility. As a result of the many meetings, it is certain that each group was better able to understand all of the problems involved. It was felt that the standards as finally proposed were more workable than any that could have been proposed without the advantage of such meetings.

On Apr. 5, 1956, the committee submitted to the California Public Utilities Commission the service rules and standards as proposed by the committee; on June 12 they were adopted, and they took effect on Jul. 1, 1956.

NARUC Standards

In August 1953, by authorization of the directors of the American Water Works Association, a committee was created to cooperate with a NARUC engineering committee on proposed standard rules and regulations governing water service. At the 1955 Annual Conference in Chicago, a report was submitted by the chairman, John H. Murdoch Jr. In his report, Murdoch commented on various sections of the NARUC report. Set out below is a comparison of some of those sections with the standards as proposed by the committee of the California Section:

1. *Information available to customers:*

NARUC: The utility shall make available to customers a copy of the state or other law governing the commission.

California: No such requirement.

2. *Discontinuance of service:*

NARUC: There does not appear any language under this section which would authorize discontinuance of service for wastage of water under emergency conditions except after 7 days' notice. The utility shall restore service "promptly" after cause of discontinuance has been corrected.

California: Where safety of water supply is endangered, service may be discontinued "immediately" without notice. The utility shall, without "unreasonable delay" restore service after cause of discontinuance has been corrected.

3. *Pressures:*

NARUC: In no event should pressure at the customer's service pipe under normal conditions fall below 25 psig, nor should the static pressure exceed 125 psig.

California: The utility shall maintain normal operating pressures of not less than 25 psig nor more than 125 psig at the service connections, except that during periods of hourly maximum demand the pressure at the time of peak seasonal loads may be not less than 20 psig and during periods of hourly minimum demand the pressure may not be more than 150 psig. Variations in pressures under normal operation shall not exceed 50 per cent of the average operating pressure.

4. *Dead ends:*

NARUC: Mains with dead ends shall be flushed as often as is necessary to maintain the quality of the water, but in any event shall be flushed at least once each 6 months.

California: Mains with dead ends shall be flushed as often as necessary to maintain the proper quality of the water.

5. *Inspection of service pipe:*

NARUC: In the installation of a service line the customer shall leave the trench open and pipe uncovered until it is inspected by the utility or other duly authorized agency and shown to be free from any tee, branch, connection irregularity, or defect.

California: No such requirement.

6. *Inspection of customer's plumbing:*

NARUC: The utility shall make a thorough inspection of customer's plumbing before making a service connection and shall not make a connection when plumbing is unsanitary or unsafe. Where adequate inspection is required and made by a governmental agency, the utility may be relieved of making an inspection.

California: No such requirement.

Meter Standards

Phases of the California committee's proposed standards relating to meters are discussed below, as follows:

1. *Determination of accuracy of meters:* Meters are to be tested at three or more test flows: one at the minimum test flow, one at 10 per cent of the maximum normal test flow limit, and one at a rate of over 35 per cent of the maximum normal test flow limit. A meter will not be placed in service if it registers less than 95 per cent of the water at the minimum test flow, or overregisters or underregisters more than 1½ per cent in the normal test flow limits, with the exception that a repaired meter is to register not less than the following appropriate percentage of the water passed through it at the minimum test flow and will not overregister or underregister more than 2 per cent in the normal test flow limits: 90 per cent, if manufactured on or after Jan. 1, 1947; and 85 per cent if manufactured prior to Jan. 1, 1947. Meters manufactured subsequent to Jan. 1, 1947, were manufactured in accordance with AWWA standards to register not less than 95 per cent of the water at the minimum test flow. Meters manufactured prior to Jan. 1, 1947, however, were not manufactured to register more than 90 per cent at the minimum test flow. This accounts for the difference in the required registration for meters manufactured before Jan. 1, 1947, as compared with the required registration for meters manufactured after that date.

2. *Meters tested at request of customer:* Meters tested at the request of a customer will be tested at the three rates of flow and, in addition, at twice the minimum test flow. The average meter error will be considered to be the algebraic average of the errors of the three highest test flows.

3. *Periodic test of meters:* Periodic tests of water meters will be based upon a consideration of relevant economic factors and accuracy of meters. The utilities will have a 5-year grace period within which to adopt a test period for periodic tests of meters. If such a test period is not adopted by a utility, the test period will automatically be 10 years. Moreover, if a company adopts a 5-year grace period, it will be necessary for the utility to be reasonably engaged in the study prior to the adoption of such a test period, or to be await-

ing commission authorization with respect to the request therefor submitted to the commission. Each utility will make a yearly summary to the commission of all periodic tests of meters.

Standards of Design

In California there are approximately 470 privately owned water utilities, all of which operate under the jurisdiction of the California Public Utilities Commission. A substantial number of these utilities have less than 1,000 customers and quite a few have less than 100 customers. Very few companies have their own engineering forces and in many cases the utility is operated by a part time employee. A section on standards of design was added to be used as a guide by these small utilities. Included as part of this section are: a pipe size determination chart (Fig. 1), from which a utility could determine size of pipe to use or the number of customers a pipe would serve each under certain given conditions; a water supply requirements chart (Fig. 2), which would show the amount of water a system should be designed for, depending on the number of customers and type of service needed; and a list of suggested approved materials.

Extension of Service

A committee of the California Section, headed by Philip F. Walsh of Southern California Water Company, directed the activities of a California industry committee, in cooperation with the staff members of the commission, to promulgate successfully a new main extension rule, which became effective in 1954 for all regulated water utilities in the state of California. The proposed standards require that each water utility shall file with the commission the main extension rule.

Under the old rule the subdivider advanced only the cost of the main and advances were refunded at 35 per cent of net revenues over a period not to exceed 10 years. Under the new rule, the subdivider advances the cost of the mains, services, and fire hydrants and advances are refundable at 22 per cent of net revenues over a period not to exceed 20 years. If additional facilities are required specifically to provide

TABLE 1

Comparison of Old and New Rules on Main Extension

Item	Old Rule		New Rule	
	Total $	Per Lot $	Total $	Per Lot $
Subdivider's advance	$34,294	$ 96	$53,910	$151
Utility's investment	26,776	75	7,160	20
Total	61,070	171	61,070	171
Cash position				
Total gross revenue	15,500		15,500	
Total expenses	11,500		11,500	
Net revenue	4,000		4,000	
Annual refund	5,430		3,420	
Deficit	1,430			
Excess			580	

pressure or storage exclusively for the service requested, the cost of such facilities may be included in the advance upon approval by the commission. Studies have shown that under the 35 per cent, 10-year rule, a utility did not have sufficient net income from services installed in connection with the main extension rule to make the necessary refunds, but had constantly to borrow new money from one source or another to make the full refund. Under the provisions of the new rule, this is no longer necessary. This point was illustrated by Walsh in Table 1, which gives an example to compare the old and new rules. Particular attention is called to the fact that of a total investment per lot of $171 under the new rule, because of the inclusion of new facilities in the advance, the utility's initial investment would be $20, and under the old rule it would be $75.

Other Provisions

Water utilities under the jurisdiction of the commission shall not be subject to any civil liability for damages, which liability would not exist if the rules had not been adopted.

Where the application of the rules results in undue hardship or expense to a utility, it may request specific relief from the commission.

Conclusion

The complete text of the rules, as adopted by the California Public Utilities Commission, follows. It may be decided, after a few years' experience, that modifications are necessary; nevertheless, these rules represent a good start toward the standardization of services and operations of water utilities.

Rules Governing Water Service Including Minimum Standards for Design and Construction

General Order No. 103, Public Utilities Commission of the State of California.

I. General

1. *Intent:*

a. *Purpose.* The purpose of these rules is to promote good public utility practices, to encourage efficiency and economy and to establish minimum standards to be hereafter observed in the design, construction, and operation of water works facilities by water utilities operating under the jurisdiction of the commission. The standards herein prescribed are intended as minimum standards applicable after adoption and continued full utilization of existing facilities is contemplated. Nothing contained in any of the rules herein promulgated shall be construed to require the replacement or abandonment prior to the expiration of economic utilization of facilities in use at the time of adoption of these rules unless the commission, after hearing, shall enter an order directing the abandonment or replacement of particular facilities found to be inadequate for the rendition of proper public utility service.

b. *Absence of civil liability.* These rules are adopted by the commission to establish minimum standards in relation to the design, construction, and opera-

tion of water works facilities by water utilities operating under the jurisdiction of the commission. Such establishment shall not impose upon these utilities, and they shall not be subject to, any civil liability for damages, which liability would not exist at law if these rules had not been adopted.

2. *Applicability.* .These rules are designed primarily for utility systems supplying potable water under pressure but shall apply insofar as they may be appropriate to utility systems supplying water not intended or claimed to be potable from ditches, canals or other conduits. The paragraphs of these rules applicable to utility systems supplying such nonpotable water are set forth in Appendix A hereto.

3. *Definitions:*

a. *Commission.* In the interpretation of these rules the word "commission" shall be construed to mean the Public Utilities Commission of the State of California.

b. *Utility.* Any person, firm, or corporation, their lessees, trustees, receivers or trustees appointed by any court whatsoever, owning, controlling, operating, or managing any water system within this State, who sells, leases, rents, or delivers water to any person, firm, corporation, municipality, or any other political subdivision of the State, whether under contract or otherwise, is a public utility, except as provided in Sections 2704, 2705 and 2706 of the Public Utilities Code.

c. *Customer.* The word "customer" shall be construed to mean any person, firm, association, corporation or governmental agency supplied or entitled to be supplied with water service for compensation by a utility.

d. *Meter.* The word "meter" shall be construed to mean any device used for the purpose of measuring the quantity of water delivered by a utility to a customer.

e. *Service pipe.* The term "service pipe" shall be construed to mean the connection between the utility's mains and the service connection and shall include all of the pipe, fittings, and valves necessary to make the connection.

f. *Service connection.* The term "service connection" shall be construed to mean the point of connection of the customer's piping or ditch with the meter, service pipe, or ditch owned by the utility.

4. *Information available to public.* The utility shall maintain, open for public inspection, at its more important commercial offices pertinent information regarding the service rendered, including the following:

a. *Characteristics of water.* A description in writing of the kind of water to be furnished, whether filtered or unfiltered and whether treated or untreated and the extent thereof

b. *Rates and rules.* A copy of the tariff schedules consisting of rates, general rules of the utility, service area maps, and forms of contracts and applications applicable to the territory served from that office

c. *Reading meters.* Information about method of reading meters

d. *Bill analysis.* A statement of the past readings of the meter or meters serving a customer's own premises for a period of two years.

5. *Access to property.* The utility shall at all reasonable hours have access to meters, service connections, and other property owned by it which may be located on customer's premises for purposes of installation, maintenance, operation, or removal of its property at the time service is to be terminated. The customer's system should be open for inspection at all reasonable times to authorized representatives of the utility. Any employee of the utility whose duties require him to enter the customer's premises shall wear a distinguishing uniform or other insignia, identifying him as an employee of the utility, or carry on his person a badge or other identification which will identify him as an employee of the utility, the same to be shown by him upon request.

6. *Discontinuance of service:*

a. *For noncompliance with rules.* No utility shall discontinue service to any

customer for violation of its rules without first having diligently tried to induce the customer to comply with its rules on file with the commission. After such effort on the part of the utility, service may be discontinued after the utility has given the customer at least 5 days' written notice of such intention either by mail or by leaving such notice in a conspicuous place at the customer's premises. Where safety of water supply is endangered, service may be discontinued immediately without notice.

b. *For nonpayment of bills.* No utility shall discontinue service to any customer for nonpayment of bills (including delayed payment charges) without first having diligently tried to induce the customer to pay same. After such effort on the part of the utility, service may be discontinued after the utility has given the customer at least 5 days' written notice of such intention in the manner provided in the preceding paragraph.

c. *For unsafe apparatus or where service is detrimental or damaging to the utility or its customers.* If an unsafe or hazardous condition is found to exist on the customer's premises, or if the use of water thereon by apparatus, appliances, equipment or otherwise is found to be detrimental or damaging to the utility or its customers, the service may be shut off without notice, provided that the utility shall notify the customer immediately of the reasons for the discontinuance and the corrective action to be taken by the customer before service can be restored.

d. *For fraudulent use of service.* When the utility has discovered that a customer has obtained water service by fraudulent means, or has diverted the water service for unauthorized use, the service to that customer may be discontinued without notice. The utility shall not be required to restore service until the customer has complied with all filed rules and reasonable requirements of the utility and the utility has been reimbursed for the full amount of the service rendered and the actual cost to the utility incurred by reason of the fraudulent use.

e. *Reconnection.* In all cases of discontinuance of service as herein defined, and after the cause for discontinuance has been corrected, and all rules of the utility on file with the commission have been complied with, the utility shall, without unreasonable delay, restore service to the customer.

f. *Charge for reconnection.* Where service has been discontinued for violation of rules or for nonpayment of bills, the utility may charge $2.50 for reconnection of service during regular working hours or $5.00 for reconnection of service at other than regular working hours when the customer has requested that the reconnection be made at other than regular working hours.

7. *Refusal to serve:*

a. *Conditions for refusal.* The utility may refuse to serve an applicant for service under the following conditions:

(1) If the applicant fails to comply with the rules of the utility as filed with the commission

(2) If the intended use of the service is of such a nature that it will be detrimental or injurious to the service furnished to existing customers

(3) If, in the judgment of the utility, the applicant's installation for utilizing the service is unsafe or hazardous, or of such a nature that satisfactory service cannot be rendered

(4) Where service has been discontinued for fraudulent use, it shall be the duty of the utility before making service connections to a new customer to ascertain that prior fraudulent use of the facilities will not be attributed to the new customer. Where service has been discontinued for fraudulent use, the utility shall not be required to serve an applicant until the utility has determined that all conditions of fraudulent use or practice have been corrected.

b. *Notification to customers.* When an applicant is refused service under the provisions of this rule, the utility shall notify him promptly of the reason for the refusal to serve and of his right to appeal the utility's decision to the commission.

8. *Complaints.* Upon complaint to the utility by a customer either at its office, by letter, or by telephone, the utility shall promptly make a suitable investigation and advise the complainant of the results thereof. It shall keep a record of all complaints which shall show the name and address of the complainant, the date and nature of the complaint, and the adjustment or disposition thereof for a period of 2 years subsequent to the final settlement of the complaint. After 2 years the utility shall keep at its option either the original complaints or a summary of such complaints for an additional three years. Complaints with reference to rates or charges which require no further action by the utility need not be recorded.

9. *Accidents.* The utility shall cooperate with the commission to promote a reduction in hazards within the industry and to the public. The utility shall keep a record of any accident endangering the public in general, or its employees, or disrupting the facilities for supplying water to the public which may have caused substantial property damage, serious personal injury or death, which shall be available for inspection by the commission for the period prescribed by the California Code of Civil Procedure for the commencement of actions thereon but in no instance less than 5 years. The utility shall assist the commission in the event of an investigation by the commission staff.

10. *Records and reports:*

a. *System maps.* Each utility shall have on file at its principal office located within the state, drawings, maps or other permanent records for the purpose of aiding in the operation of the water system. The scale of such maps or drawings shall be such that all data recorded thereon shall be clear and legible. These records, unless the commission otherwise authorizes, shall show the following:

(1) Location of all principal pumping stations, diversion works, water treatment and filter plants, sources of supply, storage facilities, size, character, and location of all mains and ditches, including valves and gates, gages, interconnections with other systems, and fire hydrants

(2) Location, size, and kind of each service pipe

(3) Layout of all principal pumping stations, water treatment and filter plants to show size, location and character of all major equipment, pipelines, connections, valves, and other equipment used in connection therewith

(4) The date of construction of all principal items of plant and extensions of main.

b. *Location of records.* All records required by these rules shall be kept at the principal office of the utility or other suitable storage place located within the state and shall be made available to representatives, agents or employees of the commission upon reasonable notice and at all reasonable hours

Reports to the commission. The utility shall furnish to the commission, at such times and in such form as the commission may require, the results or summaries of any tests required by these rules. The utility shall also furnish the commission with any information concerning the utility's facilities or operations which the commission may request and need for determining rates or judging the practices of the utility.

11. *Deviations from any of these rules.* In those cases where the application of any of the rules incorporated herein results in undue hardship or expense to the utility, it may request specific relief by filing a formal application in accordance with the commission's rules of procedure, except that where the relief to be requested is of minor importance or temporary in nature, the commission may accept an application and showing of necessity by letter.

II. Standards of Service

1. *Quality of water:*

a. *General.* Any utility serving water for human consumption or for domestic uses shall provide water that is wholesome, potable, in no way harmful or dangerous

to health and, insofar as practicable, free from objectionable odors, taste, color, and turbidity. Any utility supplying water for human consumption shall hold or make application for a permit as provided by the Health and Safety Code of the state of California, and shall comply with the laws and regulations of the state or local department of public health. It is not intended that any rule contained in this paragraph II 1 shall supersede or conflict with an applicable regulation of the State Department of Public Health. A compliance by a utility with the regulations of the State Department of Public Health on a particular subject matter shall constitute a compliance with such of these rules as relate to the same subject matter except as otherwise ordered by the commission.

b. *Water supply.* In the absence of comparable requirements of the State Department of Public Health, the following general rules shall apply:

(1) *Source.* Water supplied by any utility shall be:

(a) Obtained from a source free from pollution; or obtained from a source adequately purified by natural agencies; or adequately protected by artificial treatment

(b) From a source reasonably adequate to provide a continuous supply of water

(c) Of such quality as to meet the United States Public Health Service Drinking Water Standards of 1946.

(2) *Operation of supply system:*

(a) The water supply system, including wells, reservoirs, pumping equipment, treatment and filtration works, mains, meters, and service pipes shall be free from sanitary defects.

(b) No physical connection between the distribution system of a public potable water supply and that of any other water supply shall be permitted except in compliance with the Regulations Relating to Cross-Connections of the State Department of Public Health contained in Title 17 of the California Administrative Code.

(c) The presence of algae, crenothrix, and other growths in the water shall be controlled by proper treatment.

c. *Testing of water:*

(1) *Test.* Each utility shall have representative samples of the water supplied by it examined by the state or local department of public health or by an approved water laboratory as defined in Title 17 of the California Administrative Code, at intervals specified by the state or local department of public health, in accordance with the United States Public Health Service Drinking Water Standards of 1946.

(2) *Reports of tests.* The commission shall be promptly notified in writing by the utility and supplied with a preliminary report describing the situation when matters of water quality are under review by the state or local health department as a result of not meeting the United States Public Health Service Drinking Water Standards of 1946. A final report shall be submitted to the commission within a reasonable time after final disposition of the matter.

2. *Continuity of service:*

a. *Emergency interruptions.* Each utility shall make all reasonable efforts to prevent interruptions to service and when such interruptions occur shall endeavor to reestablish service with the shortest possible delay consistent with the safety to its customers and the general public. Where an emergency interruption of service affects the service to any public fire protection device, the utility shall promptly endeavor to notify the fire chief or other public official responsible for fire protection of such interruption and of subsequent restoration of normal service.

b. *Scheduled interruptions.* Whenever any utility finds it necessary to schedule an interruption to its service, it shall, where feasible, notify all customers to be affected by the interruption, stating the approximate time and anticipated duration of the interruption. Scheduled interruptions shall be made at such hours as will provide least inconvenience to the customers consistent with reasonable operations. Where public fire protection is provided by the mains affected by the interruptions, the utility shall promptly endeavor to notify the fire chief or other

officials responsible for fire protection, stating the approximate time and anticipated duration. In addition, the fire chief or other official responsible for fire protection shall be notified promptly upon restoration of service.

c. *Record of interruptions.* Each utility shall keep a complete record of all major interruptions, both emergency and scheduled. This record shall show the cause for interruption, date, time, duration, location, approximate number of customers affected, and, in cases of emergency interruptions, the remedy and steps taken to prevent recurrence.

d. *Reports to commission.* All emergency interruptions involving an entire system, an entire separately operated system of a multisystem utility or a major portion of an entire or separately operated system shall be reported to the commission by the utility as soon as possible after occurrence by telephone or telegraph stating the cause, date, time, estimated duration, location, approximate number of customers affected, and remedial steps being taken to restore service. Written reports thereof shall be submitted to the commission within 48 hr after restoration of service giving the information outlined in subparagraph c above, together with such other data as may be appropriate under the circumstances.

3. *Pressure:*

a. *Variations in pressure.* The utility shall maintain normal operating pressures of not less than 25 psig nor more than 125 psig at the service connection, except that during periods of hourly maximum demand the pressure at the time of peak seasonal loads may be not less than 20 psig and that during periods of hourly minimum demand the pressure may be not more than 150 psig. Variations in pressures under normal operation shall not exceed 50 per cent of the average operating pressure. The average operating pressure shall be determined by computing the arithmetical average of at least 24 consecutive hourly pressure readings. In the interpretation of this rule it shall be understood that in systems of widely varying elevations a utility may undertake to furnish a service which does not comply with the foregoing specifications if the customer is fully advised of the conditions under which average service may be expected, and the customer's agreement secured in writing. It shall be understood that this waiver shall not deny the right of the customer to request a service more nearly comparable to that furnished to the balance of the system, nor the Commission's right to require a better service when, upon investigation, it appears right and proper that such betterments should be made.

b. *Pressure gages.* Each utility shall provide itself with one or more recording pressure gages for each separately operated system for the purpose of making pressure surveys as required by these rules. These gages shall be able to record the pressure experienced on such system and shall be able to record a continuous 24-hr test. Each utility serving 1,000 or more customers in a separately operated system or 1,000 or more customers in any separately operated system of a multisystem utility shall maintain one or more of these recording pressure gages in service at some representative point or points on the utility's system.

c. *Pressure surveys.* At regular intervals, but not less than once each year, each utility shall make a survey of pressures in its distribution system of sufficient magnitude to indicate the pressures maintained at representative points on its system. Such surveys should be made at or near the period of maximum usage. The pressure charts for these surveys shall show the date and time of beginning and end of the test and the location at which the test was made. Records of these pressure surveys shall be maintained by the utility for a period of at least 3 years and shall be made available to representatives, agents or employees of the commission upon request.

4. *Water supply measurement:*

a. *Measuring devices.* Each utility shall install a suitable measuring device, or otherwise determine production, at each source of supply in order that a rec-

ord may be maintained of the quantity of water produced by each source.

b. *Records.* At least once each month, the quantity produced from each source of supply shall be determined. Twelve-month totals by sources shall be recorded and transmitted to the Commission in the utility's annual report to the Commission.

III. Standards of Design

1. *General.* The system shall be adequate to deliver the water requirements of all customers and meet the requirements of paragraph II 3 a.

2. *Distribution system:*

a. *Minimum pipe sizes.* The distribution system shall be of adequate size and

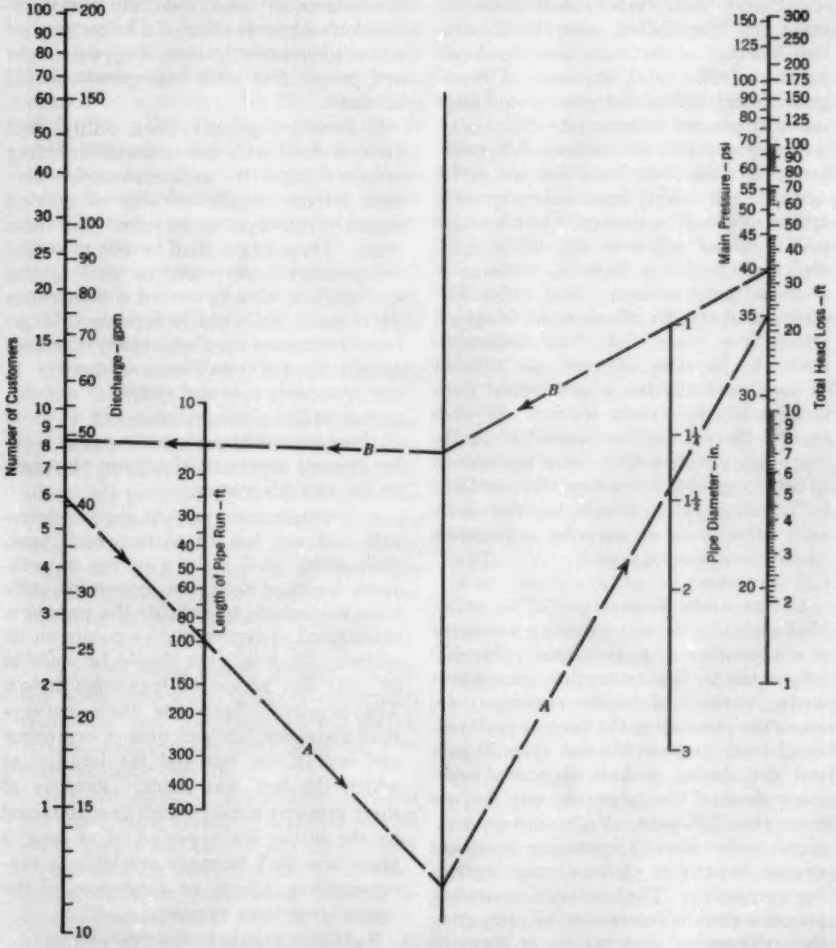

Fig. 1. Pipe Size Determination Chart

For explanation see facing page

so designed in conjunction with related facilities to maintain the minimum pressures required by paragraph II 3 a. In special cases pipes of small diameter may be installed provided the utility shall meet the requirements of the Pipe Size Determination Chart [Fig. 1] appended hereto, which chart is adopted as a part of these rules. In addition, the maximum length of small pipelines shall not exceed the following:

	Circulating *ft*	Noncirculating *ft*
1-in. nominal size	150	100
1½-in. nominal size	300	200
2-in. nominal size	500	250

b. *Fire protection.* Specifications, location, installation, and the responsibility for the maintenance of fire hydrants, public and private fire protection facilities, connecting mains, and their ownership may be subject to negotiation between the utility and the applicant. Fire hydrants and public and private fire protection facilities shall be installed to the requirements of the utility and when owned by the utility shall be subject to such conditions as the commission may determine based upon the compensation received for this service.

3. *Transmission systems.* The transmission pipelines from sources of supply shall be designed to deliver in combination with related storage facilities and to the limits of the capacity of those sources of supply the maximum requirements of that portion of the system which is dependent upon such transmission pipelines.

4. *Water supply requirements.* The quantity of water delivered to the distribution system from all source facilities should be sufficient to supply adequately, dependably and safely the total requirements of all customers under maximum consumption, and should be determined so as to maintain the specified pressures as required by paragraph II 3 a. The utility may make use of the Water Supply Requirements Chart [Fig. 2] appended hereto and made a part of these minimum standards for average requirements of service. For other than such average requirements, the results obtained from [Fig. 2] shall be supplemented as appropriate.

5. *Materials and specifications:*

a. *Qualification.* Metallic and nonmetallic materials may be used separately and in combination to construct component parts of a water system including, but not limited to, conduits, pipes, couplings, calking materials, protective linings and coatings, services, valves, hy-

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Explanation for Fig. 1 (see facing page)

Monograph assumes a minimum service pressure of 25 psi for metered customers using dead-end pipelines. For flat rate service, divide the number of customers by two; for circulating pipelines, the number of customers may be doubled on the 2-in. and 3-in. sizes. On the left scale, the number of customers N *is related to the discharge* Q *by the formula,* $Q = 15N^{0.561}$. *On the right scale, the total head loss is the actual head loss in the pipe.*

Example A*: Given number of customers (6), length of line (100 ft), and main pressure (35 psi), find pipe size. Connect points on two left scales and extend line to intersect with centerline of chart. Connect intersection with point on right scale. Read answer on pipe diameter scale (between 1¼ and 1½ in.; use 1½ in.).*

Example B*: Give main pressure (40 psi), pipe size (1 in.), and length of line (15 ft), find number of customers. Connect points on two right scales and extend line to centerline. Connecting the intersection with point on left scale, read answer on customer scale (between 8 and 9; use 8).*

drants, pumps, tanks and reservoirs; provided:

(1) The material shall have a reasonable useful service life

(2) The material shall be capable of withstanding with ample safety factors the internal and external forces to which it may be subjected in service

b. *Specification.* Materials and equipment shall be specified by a properly qualified person.

c. *Newly developed materials and equipment.* It is not the intention to prevent the use of newly developed materials and equipment that otherwise meet the requirements of paragraphs a and b, above.

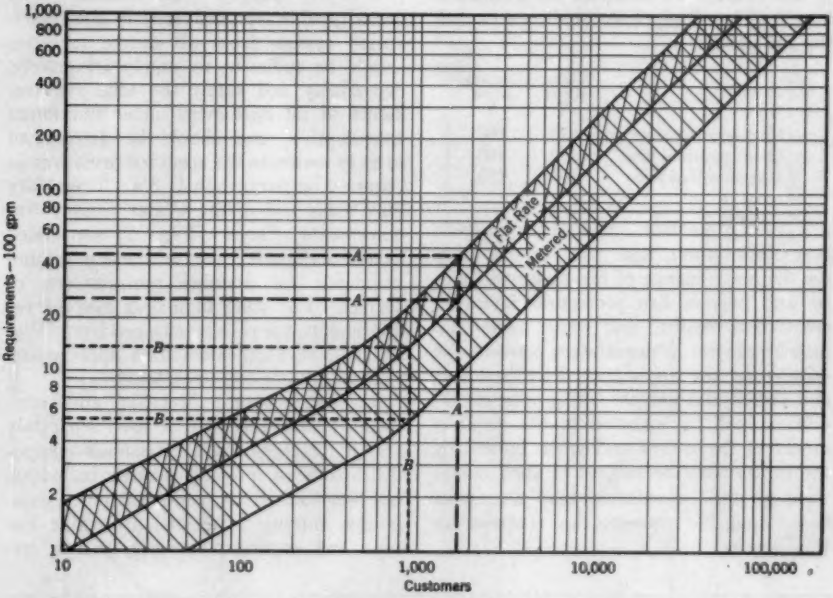

Fig. 2. Water Supply Requirements Chart

The position within each range can be determined by community background, climate, standards of living, quality and cost of water, and so forth. Example A *shows that service for 1,700 customers on a flat rate would require 2,600–4,500 gpm. Example* B *shows that 900 customers on a metered basis would require 540–1,400 gpm. The formula used for computing the curve is* Q = NCF, *where* Q *is the flow requirement in gallons per minute;* N *is the number of customers served;* C *is a constant in gallons per minute (for flat rate systems, 5–9; for metered systems, 2–5); and* F *is a factor to reflect diversity, obtained from the curve in Fig. 3.*

(3) The material shall not cause the water to become impure, unwholesome, unpotable, or unhealthful

(4) Materials and equipment shall be so selected as to mitigate corrosion, electrolysis, and deterioration.

d. *Minimum requirements for steel pipeline.* The requirements as set forth in paragraphs a, b, and c, above, are intended to be general in nature in order to permit full discretion in the selection of proper materials and equipment by the

qualified person. However, in distribution and transmission systems the following minimum requirements shall be met in the design of steel pipelines.

(1) *Outside coating.* Any of the following, except that those portions laid above ground may be protected on the outside after cleaning by painting only:

(a) Coal-tar enamel wrapped as specified by American Water Works Association [Standard No. C203]

(b) Asphalt with asbestos felt or fiberglass wrapping in accordance with the specifications shown in Appendix B

(c) Reinforced concrete in accordance with American Water Works Association [Standard] No. C205.

(2) *Inside lining.* Any of the following:

(a) Coal-tar enamel in accordance with American Water Works Association [Standard No. C203]

(b) Asphalt as specified in the specifications shown in Appendix B

(c) Cement lining in accordance with American Water Works Association [Standard] No. C205 or Federal Specification WW-P-406, where applicable.

(3) *Pipes under 4-in. outside diameter.* Pipes under 4 in. in outside diameter may be dipped in asphalt after cleaning without wrapping, provided they have a minimum wall thickness of 12 gage. If wrapped outside in accordance with the specifications outlined in paragraph d(1), above, the minimum gage shall be 14 gage.

(4) *Pipes 4-in. outside diameter and larger.* The wall thickness of pipes 4-in. in outside diameter and larger shall meet the following minimum gage requirements:

(a) 4-in. OD to and including 6⅝-in. OD pipe—12 gage

(b) 7-in. OD to and including 10¾-in. OD pipe—10 gage

(c) Pipes over 10¾ in. in outside diameter shall be of 10-gage minimum steel thickness.

All such pipes shall meet the . . . of the American Water Works Association [Standard] No. C202 and be of adequate design for the existing conditions.

(5) *Exception when used for reinforcing.* Where steel pipe is used as reinforcing for cement coated and lined pipe, steel of lesser wall thickness may be used provided the design is such that the strength of the reinforced concrete is equal to the American Water Works Association [Standard] No. C202 or Federal Specifications SS-P-381 for a steel pipe of the same diameter.

IV. Standards of Construction

1. *General.* The design and construction of the utility's water plant shall conform to standard acceptable engineering practices. It shall be designed and operated so as to provide reasonably adequate and safe service to its customers and shall conform to the requirements of the state

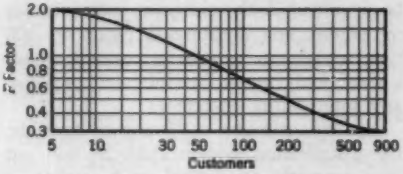

Fig. 3. Values for *F* Factor

Values for F *are taken from the above curve to apply to the formula* $Q = NCF$ *(see Fig. 2).*

or local department of public health with reference to sanitation and potability of water.

2. *Disinfection of facilities.* All new mains, pumps, tanks, wells, and other facilities for handling potable water and insofar as practicable, repaired mains and other facilities, shall be thoroughly disinfected before being connected to the system. The method of disinfection shall be as approved by the State Department of Public Health.

3. *Mains:*

a. *Depth of mains.* Water mains should be installed below the frost line or be otherwise protected to prevent freezing and shall not have less than 30 in. of cover over the top of the pipe in public streets

or alleys except where it is necessary to avoid underground obstructions or rocky or hardpan conditions where such depth is not feasible.

b. *Dead ends.* Insofar as practicable, the utility shall design its distribution system so as to avoid dead ends in its mains. Where dead ends are necessary, the utility shall provide a means for flushing the mains where the normal consumption does not provide adequate circulation of the water. Mains with dead ends shall be flushed as often as necessary to maintain the proper quality of the water.

c. *Segmentation of system.* Valves shall be provided in distribution mains at reasonable intervals so that repairs may be effected by the utility with interruptions to the service of a minimum number of customers. When feasible, valves shall be provided in the mains at intervals not to exceed one continuous block or 500 feet, whichever is greater, except where a dead end run is not intended to serve any intervening customers.

d. *Grid systems.* Wherever feasible, the distribution system shall be laid out in a properly segmented grid so that in case of breaks or repairs the interruption to service to the customers can be kept to a minimum in number.

4. *Service connections:*

a. *Size of service pipe.* The size, design, material and installation of the service pipe shall conform to the reasonable requirements of the utility, provided, however, that the minimum size of the pipe shall not be less than ¾-in. nominal size. The utility may require the customer to provide such data as may be necessary for the utility to properly size a service larger than ¾-in. nominal size consistent with the requirements of paragraph II 3 a. The utility in installing ¾-in. and 1-in. services may use the following formula as a guide provided the requirements of paragraph II 3 a are met:

¾-In. Service
Residential lot area—Metered service—8,000 sq ft; Flat rate service—10,000 sq ft
Business—Not over 10 outlets and only one flushometer toilet.

1-In. Service
Residential lot area—Metered service—8,000–20,000 sq ft; Flat rate service—10,000–25,000 sq ft
Business—From 10 to 30 outlets and from 1 to 2 flushometer toilets.

b. *Depth of service pipe.* Except in unusual conditions all service pipes shall be laid at a depth sufficient to prevent freezing, except where services are not intended for use during freezing weather and are actually drained prior to such weather, and at a depth of not less than 18 in. except at its termination in connecting with the meter or customer's piping.

V. Extension of Service

1. *Mains.* Each utility shall file with this commission as a part of each of its regularly filed tariff schedules a main extension rule in conformity with Decision No. 50580 of this commission dated Sep. 28, 1954, and as reported in 53 Cal. PUC Page 490.

2. *Service connections:*

a. *Ownership of service:*

(1) *Charge for service connections.* The utility shall make no charge to a customer for making a service connection except in case of connections for private fire protection service, connections for temporary service, or where for irrigation service additional connections are requested for the convenience of the customer or because of divisions of land ownership when the land before division was receiving irrigation service.

(2) *Utility's responsibility.* In urban areas with dedicated front streets, rear service roads, or public utility easements, the utility shall furnish and install the service pipe, curb stop, meter, and meter box at its own expense for the purpose of connecting its distribution system to the customer's piping, except, for temporary services, and as otherwise provided in the utility's main extension rules. The service connection, curb stop, meter, and meter box may be installed at a convenient

place between the property line and the curb, or inside the customer's property line where necessary. The service connection shall determine the point of delivery to the customer of water service by the utility. No rent or other charge will be paid by the utility where such utility owned service facilities are located on a customer's premises. In areas which do not have dedicated front streets, rear service roads, or public utility easements the utility shall furnish and install the service pipe, curb stop, meter, and meter box at a convenient point on or near the customer's property except for service beyond the service area.

(3) *Customer's responsibilities precedent to receiving service.* The customer as a condition precedent to receiving service shall furnish and lay the necessary piping to make the connection from the service connection to the place of consumption and shall keep such piping in good repair in accordance with such reasonable requirements of the utility as may be incorporated in its rules. A main valve shall also be provided by the customer on his piping between the service connection and the point of use. Where service is rendered at or near the service area boundary for use beyond the service area the customer will be required to install, operate and maintain the facilities necessary to provide service.

b. *Location of service.* The customer's piping shall extend to that point on the curb line or property line easiest of access to the utility from its existing distribution system or requiring the least extension of the existing distribution main. The utility should be consulted before installation thereof and its approval of location secured.

VI. Measurement of Service

1. *Method of measuring service:*

a. *Metering.* All water sold by a utility shall be upon the basis of metered volume sales except that the utility may at its option provide flat rate or estimated service for the following:

(1) Residential, business, commercial, industrial (in special situations), and irrigation service after authorization has first been obtained from the commission

(2) Temporary service where the water use can be readily estimated

(3) Public and private fire protection service

(4) Water used for street sprinkling and sewer flushing, when provided for by contract between the utility and the municipality or other local governmental authority.

b. *Registration of meter.* All meters used for metered sales excluding sales from irrigation systems or other irrigation sales shall have registration devices indicating the volume of water in either cubic feet or United States gallons. Where a constant or multiplier is necessary to convert the meter reading to cubic feet or gallons, the constant shall be indicated on the meter or on the meter reading sheet.

c. *Irrigation meters.* Irrigation service may be provided with meters which measure in acre-feet or miner's inch-days. This service may also be rendered on a volume basis by the use of a calibrated orifice such as the miner's inch box, by the use of weirs, or otherwise measured as provided in applicable tariff schedules.

d. *Charge for meter installation.* No utility shall charge for its installation of any devices for metering service to a customer, except for temporary service where the utility may charge its actual cost of installation and removal of its metering devices or where irrigation service is rendered through more than one outlet for the convenience of the customer.

2. *Meter test facilities and equipment:*

a. *Test facilities.* Each utility furnishing metered water service shall provide the necessary standard facilities, instruments, and other equipment for testing its meters in compliance with these rules. Any utility may be excepted from this requirement provided that satisfactory arrangements are made for test of its meters by another utility or agency equipped

to test meters in compliance with these rules.

b. *Shop equipment.* The meter test shop shall be provided with the necessary equipment to test up through 2-in. displacement meters, including a quick-acting valve for controlling the starting and stopping of the test and a device for regulating the flow of water through the meter under test. The accuracy of the test equipment and test procedures shall be sufficient to enable shop test of displacement meters with an error not to exceed 0.3 of 1 per cent.

c. *Test measurement standards.* Measuring devices for test of meters shall consist of calibrated tanks for volumetric measurements, tanks mounted upon scales for weight measurement or standard meters.

(1) *Basic standards.* When a volumetric tank is used, it shall be accompanied by a certificate of accuracy acceptable to the commission from a county sealer of weights and measures or from a standards laboratory. When a weight standard is used, the scales shall be tested and calibrated at least once every year by such approved laboratory, or county sealer of weights and measures and a record maintained of the results of the test. Standard meters may be used for field tests of meter accuracy provided they are tested and calibrated to permit the test of meters within the limits of accuracy required by these rules, either by the utility with its volumetric or weight standard equipment or by an approved laboratory at least once every 60 days while the standard meter is in use and a record of such tests shall be kept by the utility for a period of not less than 5 years.

(2) *Size of basic standards.* When basic standards are used for meter tests, they shall be of a capacity sufficient to insure accurate determinations. The minimum requirement for testing disc meters from ⅝ x ¾-in. through 2 in. in size shall include a 10- and a 1-cu ft tank for meters registering in cubic feet or a 100- and a 10-gal tank for meters registering in gallons.

3. *Accuracy requirements of water meters:*

a. *General.* All meters used for measuring quantities of water delivered to customers shall be in good mechanical condition, shall be adequate in size and design for the type of service which each measures and shall be accurate to within generally accepted standards. The standards of accuracy for displacement meters are set forth in paragraphs b and c, following.

b. *Test Flows.* For determination of minimum test flow and normal test flow limits, the commission adopts as a guide the appropriate standard . . . of the American Water Works Association for the various types of meters.* These test flows for displacement type cold water meters are as follows:

Nominal Meter Size *in.*	Minimum Test Flow *gpm*	Normal Test Flow Limits *gpm*
⅝ or ¾ × ¾	¼	1–20
¾	½	2–30
1	¾	3–50
1–½	1–½	5–100
2	2	8–160
3	4	16–300
4	7	28–500
6	12	48–1000

c. *Determination of accuracy.* Displacement meters shall be tested at three or more test flows: one at the minimum test flow, one at 10 per cent of the maximum normal test flow limit and one at a rate over 35 per cent of the maximum normal test flow limit. A meter shall not be placed in service if it registers less than 95 per cent of the water passed through it at the minimum test flow or over- or underregisters more than 1½ per cent in the normal test flow limits; with the exception that a repaired meter shall register not less than the following appropriate percentage of the water

* AWWA Standards C700 through C704 cover various types of meters. Tentative AWWA Standard C705 covers the testing of cold-water meters.—Ed.

passed through it at the minimum test flow and shall not over- or underregister more than 2 per cent in the normal test flow limits,

If manufactured on or after Jan. 1, 1947 —90 per cent
If manufactured prior to Jan. 1, 1947—85 per cent

d. *Sealing of meter.* Upon completion of adjustment and test of any water meter under the provisions of these rules, the utility shall affix thereto a suitable seal in such a manner that adjustment or registration of the meter cannot be tampered with without breaking the seal.

e. *Record of test.* A complete record of all displacement and other mechanical meter tests and data sufficient to allow checking of test calculations, shall be recorded by the meter tester. Such record shall include: the identifying number of the meter; the type and size of the meter; the constant of the meter; the date and kind of tests made; the reading of the meter before making any test; the error as found at each test; and, if readjusted, the percentage of registration as left after each test. The complete record of tests of each meter shall be retained for at least 5 years.

4. *Initial tests and storage of meters.* Every water meter shall be tested as required by these rules prior to its installation either by the manufacturer, the utility or any reliable organization equipped for meter testing. Each meter should be stored in an inverted position, and unless so stored it shall be so tested immediately before installation.

5. *Repaired or tested meters.* All water meters removed from service for repair or tested in accordance with these rules shall be restored to the prescribed limits of accuracy as required by these rules before again being placed in service.

6. *Periodic tests of water meters:*

a. *General.* The length of time that a meter shall be allowed to remain in service before receiving test and repair should be determined from an economic analysis.

b. *Test periods:*

(1) *Adoption of test periods by utility.* A utility may adopt a test period for the periodic test of meters within any well defined separate system as the utility may deem appropriate, based upon a consideration of relevant economic factors and accuracy of meters, provided authorization for such test period for any such separate system is first obtained from the commission. Requests for such authorization may be made by an application and showing of necessity by letter.

(2) *Test periods if not adopted by utility.* Unless a test period for such periodic tests of meters shall have been adopted as provided in paragraph (1), above, no meter shall be allowed to remain in service more than 10 years from the time when last tested without again being retested in the manner provided by these rules. Nothing in these rules shall be construed to mean that such periodic tests may not be made more frequently than once in every 10 years.

(3) *Meters in service at the time these rules become applicable.* Each utility shall test its meters installed previous to the time these rules become applicable progressively over the next succeeding 10-year period from such time or over such other period as may be adopted as provided in paragraph (1), above, as the applicable periodic test period within any well defined separate system. The order of test of these meters shall be such that those in service the longest period of time over the applicable periodic test period from the time when last tested shall be tested first whenever feasible.

(4) *Provision for initial 5-year grace period.*—When application is to be made for authorization of a test period under paragraph (1), above, the utility shall have a period of 5 years from the effective date of these rules within which to adopt a test period for the periodic test of meters within any well defined separate system as the utility may deem appropriate and the provisions of paragraphs (2) and (3), above, shall not be applicable to the

utility during such 5-year period so long as the utility shall be reasonably engaged in the work necessary to the adoption of such test period or shall be awaiting commission authorization with respect to a request therefore submitted to the commission. When such application is to be made hereunder and the utility desires to avail of such 5-year period the utility shall notify the Commission in writing within 1 year from the effective date of these rules.

c. *Report of periodic tests of meters.* Each utility shall make a summary of all periodic tests of meters made each calendar year as required by these rules and shall submit such summary to the commission by not later than March 15th of the year following.

7. *Tests on customer request:*

a. *Compliance by utility.* The utility shall within 1 week after request by a customer proceed to test the meter serving his premises, except where service is rendered from open conduits such test may be deferred for a reasonable length of time when it would necessitate the interruption of service to any other customer. Such test of meters other than displacement meters shall consist of an acceptable method of verifying the accuracy of the meter.

b. *Charge for test.* No charge shall be made for such a test, except where a customer requests a test within 6 months after installation of the meter or more often than once a year, in which cases the customer shall be required to deposit with the utility the following amount to cover the cost of each such test:

Size of Meter	Amount of Deposit
One inch or smaller	$2.00
Larger than one inch	3.50

c. *Test procedure.* Every meter tested at the request of a customer shall be tested in the condition as found in the customer's service prior to any alteration or adjustment in order to determine the average meter error. This test shall consist of testing at the three rates of flow as determined in paragraph 3 c, above, and in addition, at twice the minimum test flow. The average meter error shall be considered to be the algebraic average of the errors of the three highest test flows.

d. *Return of deposit.* Any deposit made under paragraph b, above, will be returned to the customer if the average meter error is found to be more than 2 per cent fast. The customer will be notified not less than 5 days in advance of the time and place of the test.

e. *Location of test.* A customer shall have the right to require the utility to conduct the test in his presence or in the presence of his representative. Where the utility has no proper meter testing facilities available locally, the meter may be tested by a meter manufacturer or its agency, or by any other reliable organization equipped for water meter testing or by the utility's meter testing plant where located in some other community, in which latter case the utility upon demand of the customer shall furnish the customer with a notarized statement certifying as to the method used in making the test and as to the accuracy of the meter.

f. *Report of test to customer.* A report showing the results of the test shall be furnished to the customer within 15 days after the completion of the test.

8. *Meter records.* Each utility shall keep records giving for each displacement and other mechanical meter owned and used by it for any purpose the identification number, name of manufacturer, serial number, type, size, and the address of the premises where the meter has been in service, with dates of installation and removal. These records shall also give condensed information concerning all tests including dates. The records shall be maintained in a manner such that the date of the last test is readily determinable.

VII. Rates and Billing

1. *Filing of Tariffs.* Each utility shall file with the commission its tariff sched-

ules containing all tariff sheets in accordance with the procedure provided for in General Order 96.

2. *Information on bills.* Each utility shall render a bill to each customer for each billing period. Bills for metered service shall show at least the reading of the meter at the end of the period for which the bill is rendered, the meter constant, if any, the number and kinds of units, and date of the current meter reading.

3. *Adjustment of bills for meter error:*

a. *Fast meters.* When, upon test, a meter is found to be registering more than 2 per cent fast, the utility shall refund to the customer the amount of the overcharge based on corrected meter reading for the period the meter was in use but not to exceed a period of 6 months.

b. *Slow meters:*

(1) *Commercial service.* When, upon test, a meter used for commercial (residential and business) service is found to be registering more than 25 per cent slow, the utility may bill the customer for the amount of the undercharge based upon corrected meter readings for the period the meter was in service but not to exceed a period of 3 months.

(2) *Other than commercial service.* When, upon test, a meter used for other than commercial service, is found to be registering more than 5 per cent slow, the utility may bill the customer for the amount of the undercharge based upon corrected meter readings for the period the meter was in service but not to exceed a period of 3 months.

c. *Nonregistering meters.* The utility may bill the customer for water consumed while the meter was nonregistering, but not to exceed a period of 3 months, at the minimum monthly meter rate, or upon an estimate of the consumption based upon the customer's prior use during the same season of the year if conditions were unchanged, or upon an estimate based upon a reasonable comparison with the use of other customers during the same period receiving the same class of service under similar circumstances and conditions.

d. *General.* When it is found that the error in a meter is due to some cause, the date of which can be fixed, the overcharge or the undercharge shall be computed back to but not beyond such date.

APPENDIX A

Nonpotable Water Supply

[The following sections of these rules] shall be applicable to utility water systems supplying water not intended or claimed to be potable from ditches, canals, or other conduits.

Section I—General: All paragraphs of the section, except items (2), (3), and (4) of paragraph 10 a.

Section II—Standards of service: Paragraphs 2 and 4 of this section, except that paragraph 2 c shall not apply to scheduled interruptions as provided in applicable tariffs.

Section III—Standards of design: None.

Section IV—Standards of construction: None.

Section V—Extension of service: Paragraph 2 a (1) of this section.

Section VI—Measurement of service: All paragraphs of the section, except when sales are measured by other than displacement meters as provided in applicable tariff schedules only paragraphs 1, 3 a and e, 5, 6 a, 7 a, e, and f and 8 shall apply.

Section VII—Rates and billing: All paragraphs of the section, except when sales are measured by other than displacement meters as provided in applicable tariff schedules only paragraphs 1, 2, and 3 c and d shall apply.

APPENDIX B

Specification for the Coating and Wrapping of Steel Water Pipe

1. *Scope:*

These specifications cover the material for the asphalt coating of steel water pipe by the double dip process and the wrapping of same with asbestos felt or fiberglass.

2. *Materials:*

Asphalt. Asphalt shall be Union Oil Company's "190 Pipe Dip,"* or an approved equivalent, and shall conform to the physical requirements set forth below. (Penetration and softening points shall meet the ASTM standard methods of test as specified under the specification Designations ASTM-D5-52 and ASTM-D36-26, respectively.)

Penetration at 115°F—0.75 cm max.
Penetration at 77°F—Not less than 0.27 cm
Penetration at 32°F—Not less than 0.20 cm
Softening point—Not less than 190°F
Flash point—Not less than 425°F
Ductility at 77°F—Not less than 2.0 cm
Solubility in CCl_4—Not less than 99.0 per cent
Loss on heating (% by weight)—0.75 max.
Penetration after loss on heating—80 per cent min.

* The American Water Works Association's standards for the protective coating of metallic pipe do not contain a reference to asphaltic derivatives as acceptable materials. It is also the basic policy of the Association not to refer to any material by trade name. It is also not the practice to refer to any product controlled by a single producer in the AWWA standard documents.—Ed.

3. *Wrapping, Asbestos Felt or Fiber Glass:*

After completion of asphalt coating of pipe it shall be machine wrapped with asbestos felt or fiber glass. The wrapping shall be completely sealed and bonded onto the dipped pipe by use of a hot asphaltic coating composition. This asphalt seal coat shall also be applied between the overlaps of the wrapping. Special sections, such as tapers, elbows, and other fittings, may be wrapped by hand. The wrapping shall be applied in a spiral manner providing a minimum overlap of ½ in. It shall be applied smoothly under suitable mechanical tension to give a good tight wrapping free from wrinkles, buckles, air pockets, and tears. At each end of each section of pipe the wrapping shall be omitted for a sufficient distance to permit making the field joints. The minimum distance shall be such as to expose at least 1 in. of asphalt.

4. *Cleaning of Pipe:*

All metal surfaces to be coated shall be thoroughly cleaned of all loose mill scale, dirt, oil, grease, rust, and other foreign matter.

5. *Transporting and Handling Coated Pipe:*

The coated pipe shall at all times be handled in such manner, and with such equipment, as will prevent any damage to the protective coating. In loading pipe for shipment, adequate blocking, cradles, braces, and padding shall be used as necessary to properly support and secure the pipe and to prevent any abrasion or other damage to the coating in transit.

American Water Works Association

TENTATIVE

AWWA STANDARD

for

COPPER SULFATE

This "Standard for Copper Sulfate" is based upon the best known experience and is intended for use under normal conditions. It is not designed for use under all conditions and the advisability of use of the material herein described in any water treatment plant must be subjected to review by the chemist or engineer responsible for operations in the locality concerned.

Approved as "Tentative" Sep. 15, 1957

● Price of reprint—20¢ per copy

● Approximate date available—Mar. 15, 1958

AMERICAN WATER WORKS ASSOCIATION
Incorporated
2 Park Avenue, New York 16, N.Y.

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This "Standard for Copper Sulfate" was prepared under the direction of James E. Kerslake for the Water Purification Division, AWWA. The standard was approved by the Executive Committee of the Water Purification Division and by the Water Works Practice Committee, and received the approval of the Association's Board of Directors on Sep. 15, 1957. It was also submitted for review to producers and consumers of the materials involved, whose comments were then considered by Benjamin C. Nesin, acting as referee.

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Tentative AWWA Standard for

Copper Sulfate

Part A—Material

Sec. 1A—Scope

This standard covers copper sulfate for use in the treatment of municipal and industrial water supplies. The standard is intended for use in connection with Part B (Sampling, Inspection, Packing, and Marking) and Part C (Testing Methods) of this document.

Sec. 2A—Definition

2A.1. The copper sulfate covered by this standard is a commercial grade of copper sulfate pentahydrate containing at least 99 per cent $CuSO_4 \cdot 5H_2O$. It is also known as blue vitriol and bluestone. The pure compound—that is, 100 per cent $CuSO_4 \cdot 5H_2O$—has the following composition: anhydrous salt ($CuSO_4$), 63.92 per cent; water of crystallization, 36.08 per cent; copper (Cu), 25.45 per cent; sulfate (SO_4), 38.47 per cent. The grade specified herein shall contain not less than 25.0 per cent of metallic copper equivalent. The above values are based upon the following atomic weights: Cu = 63.54, S = 32.066, O = 16.000, H = 1.008.

2A.2. The impurities in the commercial product may derive from both the source of copper and method of processing the salt. Impurities reported by various analysts include traces of aluminum, antimony, arsenic, bismuth, calcium, chloride, chromium, fluorine, iron, lead, magnesium, manganese, nickel, selenium, silica, silver, tellurium, and tin. With the exception of iron, none of these is likely to be present in quantities exceeding 0.1 per cent and more generally would probably be found in a range of concentration varying from less than 0.001 to 0.05 per cent.

The above commentary relating to impurities is not an essential stipulation of the standard.

2A.3. This product may be obtained in the form of transparent, deep blue, triclinic-system crystals, or as blue crystalline granules or powder. In dry air it effloresces and may lose weight due to loss of water of crystallization.

2A.4. In the range of temperatures ordinarily encountered, the solubility of $CuSO_4 \cdot 5H_2O$ varies as shown in Table 1. It has a specific gravity of 2.28, and the weight of the commercial product, depending upon the size grading and packing, may vary from 75 to 93 lb/cu ft.

TABLE 1

Solubility of $CuSO_4 \cdot 5H_2O$

Temperature	$CuSO_4 \cdot 5H_2O$ per 100 lb of solution lb	$CuSO_4 \cdot 5H_2O$ per 100 gal of water lb
0°C (32°F)	19.5	186.0
40°C (104°F)	35.2	371.1

Sec. 3A—Sampling

Sampling shall be conducted in accordance with Part B (Sampling, Inspection, Packing, and Marking) of this document.

Sec. 4A—Methods of Testing

The analytical procedures shall be carried on in accordance with Part C (Testing Methods) of this document.

Sec. 5A—Impurities

The copper sulfate supplied under this standard shall contain no soluble mineral or organic substances in quantities capable of producing deleterious or injurious effects upon the health of those consuming the water which has been treated properly with the copper sulfate.

Specifications concerning limitations upon other impurities may be made between the vendor and the purchaser.

Sec. 6A—Rejection

6A.1. Notice of dissatisfaction with a shipment as received based on the specifications must be in the hands of the consignor within 10 days after receipt of the shipment at the point of destination. If the consignor desires a retest, he shall notify the consignee within 5 days of notice of the complaint. Upon receipt of the request for a retest, the consignee shall forward to the consignor one of the sealed samples. In the event that the results obtained by the consignor on retesting do not agree with the results obtained by the consignee, the other sealed sample shall be forwarded, unopened, for analysis to a laboratory agreed upon by both parties. The results of the referee analysis shall be accepted as final, and the cost of the referee analysis shall be paid for by the party whose results show the greatest discrepancy from the referee analysis.

6A.2. On the basis of the retest or the referee's test, the consignor may remove the material from the premises of the consignee, or a price adjustment may be agreed upon by the consignor and the consignee.

Sec. 7A—Size

7A.1. Four standard sizes of copper sulfate are considered in this document, although other sizes may be specified to meet special requirements in accord with arrangements to be made between the vendor and purchaser. The sizes are designated *A, B, C,* and *D,* respectively. All sizes shall be free flowing, shall contain no foreign contaminating material, and shall meet the other requirements set forth in this standard. The sieve sizes specified herein refer to the National Bureau of Standards Sieve Series.

Size A: 100 per cent of this material shall pass a No. 8 sieve, and not less than 95 per cent shall be retained on a No. 100 sieve.

Size B: Not more than 2 per cent of this material shall be retained on a ¼-in. coarse-series screen, not less than 90 per cent shall be retained on a No. 10 sieve, and not more than 2 per cent shall pass a No. 100 sieve.

Size C: Not more than 2 per cent of the material shall be retained on a ½-in. coarse-series screen, not less than 90 per cent shall be retained on a No. 3½ sieve, and not more than 2 per cent shall pass a No. 100 sieve.

Size D: Not more than 2 per cent of the material shall be retained on a 1½-in. coarse-series screen, not less than 90 per cent shall be retained on a ½-in. coarse-series screen, and not

more than 5 per cent shall pass a No. 100 sieve.

7A.2. If more than 5 per cent of the total amount of any package of Sizes *A* and *B* as received is in cake form, the package may be rejected.

7A.3. A large number of purchasers have obtained copper sulfate by specifying commercial sizes by such designations as large crystals, small crystals, rice or granular, snow or powdered. There is no agreement among the manufacturers as to the exact screen sizes of the various grades. If the purchase is made using such designations and the size is to be checked by sieve analysis, an agreement should be made between the purchaser and the seller concerning the sieve analysis.

Sec. 8A—Chemical Composition

8A.1. The copper content shall not be less than 25.0 per cent.

8A.2. The insoluble matter shall not exceed 0.5 per cent.

Part B—Sampling, Inspection, Packing, and Marking

Sec. 1B—Scope

These procedures for the sampling, inspection, packing, weighing, and marking of copper sulfate are intended for use in connection with Part A (Material) and Part C (Testing Methods) of this document.

Sec. 2B—Sampling

2B.1. Samples shall be taken at the point of destination.

2B.2. For the purpose of sampling, shipments of material may be divided into lots, no single lot of material to exceed 100 tons. Thus, not over 100 tons of material shall be represented by a single sample.

2B.3. If the copper sulfate is handled by conveyor or elevator, a mechanical sampling arrangement may be used. In this case the material shall be handled at a reasonably uniform rate by the conveyor or elevator, and the gross or original sample shall be taken by cutting across the full stream of material at regular intervals rather than selecting at odd times a portion of the material being handled.

2B.4. If the material is packaged, 10 per cent of the packages shall be sampled, taking uniform amounts from every package sampled, and being careful to avoid taking a disproportionate amount of material from the top or bottom of any package. No sample shall be taken from a broken package.

2B.5. The gross or original sample shall not be less than 0.25 per cent of the lot represented and in no case less than 25 lb. The size of particles in the sample shall be as nearly as possible the same as in the entire shipment.

2B.6. If the gross sample is in excess of 50 lb, it may be reduced to this amount without crushing regardless of the size of the individual particles. The reduction in amount may be accomplished by standard coning and quartering procedure or through standard riffling equipment.

2B.7. After reduction of the gross sample to 50 lb, or if the original gross

sample is less than 50 lb, it may be divided into two portions, one for sieve and screening analysis, and the other for chemical analysis.

2B.7.1. The gross sample required for sieve and screening analysis shall be ten times the amount stipulated for a single test under Sec. 2C.

2B.7.2. The gross sample required for chemical analysis shall not be less than 10 lb. If it exceeds 50 lb, it shall be reduced to that weight by standard coning and quartering procedure. It shall then be crushed to pass through a ¼-in. coarse-series sieve before any further reduction in amount. Following the latter procedure the sample may be reduced to not less than 10 lb by riffling or coning and quartering procedure.

2B.8. The final 10 lb of sample shall be crushed to pass through a No. 10 sieve. After such preparation it shall be uniformly divided to provide at least five 1-lb samples, an original and reserve for the shipper and customer and a reserve to be sent to a referee if necessary. The 1-lb samples shall be sealed in airtight, moistureproof glass containers. Each sample container shall be labeled to identify it properly.

Sec. 3B—Packing and Shipping

3B.1. Copper sulfate may be shipped in 50- or 100-lb multiwall paper bags, 200- or 400-lb wooden barrels, 100- or 200-lb waterproof paper-lined burlap bags, 100–400-lb fiber drums, or in bulk in boxcars. Cars must be tight and well cleaned before loading. Every shipment shall be free from dirt, chips, and other foreign material.

3B.2. The net weight of the packages shall not deviate from the recorded weight by more than ± 2.5 per cent. If exception is taken to the weight of the material received, it shall be based on the certified weight of not less than 10 per cent of the packages shipped. The packages shall be selected at random from the entire shipment.

Sec. 4B—Marking

Each shipment of material shall carry with it some means of identification. Each package shall have marked legibly thereon the net weight of the contents, the name of the manufacturer, and a brand name if any. The package may bear also the statement: "Guaranteed by (name of manufacturer) to meet the American Water Works Association standard for copper sulfate."

Part C—Testing Methods

Sec. 1C—Scope

These methods for the examination of copper sulfate are intended for use in connection with Part A (Material) and Part B (Sampling, Inspection, Packing, and Marking) of this document.

Sec. 2C—Preparation of Tests

2C.1. *Sizing tests.* The amount of sample required in these tests depends upon the size grade involved. The following schedule of minimum amounts of sample per individual sieving and screening test is suggested:

Size Grade	Minimum Test Portion g
A	100
B	200
C	1,500
D	3,000

2C.2. *Chemical tests.* The sample which has been reduced to pass through a No. 10 sieve shall be used directly for the determination of copper. The entire 1-lb sample shall be thoroughly mixed and approximately 100 g of the material selected from the gross sample placed in a properly stoppered glass container. Any test portions selected from the 100 g are to be weighed therefrom immediately.

Sec. 3C—Electrolytic Determination of Copper

3C.1. The copper content shall be determined electrolytically, except under conditions noted in Sec. 4C.

3C.2—*Procedure:*

Weigh out test portions of approximately 5 g of copper sulfate as rapidly as possible and transfer to tall-form 400-ml beakers, washing off the glass balance pan with a stream of water from a wash bottle. Dissolve in 350 ml distilled water and then add 10 ml concentrated HNO_3 and 10 ml concentrated H_2SO_4. Allow test portions to cool to room temperature.

The copper shall be deposited electrolytically on tared, perforated, platinum cylinder cathodes, with a straight platinum wire for the anode. The beakers shall be carefully covered with split watch glasses to prevent loss by spraying.

Apply a current density of 0.5 amp/sq dm of cathode area * until deposition is complete. It is customary to conduct this operation overnight. When the solution is colorless, wash down the cover glasses, electrodes, and sides of the beaker, raising the level of the liquid slightly, and continue the electrolysis for about 15 min, noting whether or not copper is deposited on the newly exposed surface of the platinum. If copper appears, raise the level slightly and continue the electrolysis until none appears on the electrode. The completion of electrolysis may be determined by testing a few drops of the solution on a spot plate with saturated hydrogen sulfide solution. Electrolysis is complete when no copper sulfide coloration is observed.

When electrolysis is complete, remove the cathode quickly while washing with water from a wash bottle, and rinse the cathode in two successive baths of 95 per cent alcohol. Dry in oven at 110°C for 3 min, cool, and weigh as metallic copper.

3C.3—*Calculation:*

$$\frac{\text{Increased weight (g) of electrode} \times 100 \times 3.938}{\text{weight (g) of sample}} = \text{per cent } CuSO_4 \cdot 5H_2O$$

NOTE: If results obtained for copper are low, it may be desirable to save the solution from which the copper has been removed, for the electrolytic determination of nickel, which may be responsible. Commercial electroanalyzers can be obtained from laboratory supply houses located throughout the country. When making analyses, directions which come with the instrument should be followed strictly.

By consent of all parties concerned, more rapid procedures for the electrolytic determination of copper may be employed. In general, it is assumed that the procedure would follow that specified above, with the exception that

* Cathode area equals gross area of inside of cylinder, excluding perforations.

higher current densities and rotating electrodes would be used.

Sec. 4C—Volumetric Method

The electrolytic method is much less subject to error than is the volumetric thiosulfate method. Some water utility laboratories may not have the equipment for the electrolytic determination. In such instances, the purchaser and vendor may enter into an agreement to utilize the volumetric method, provided it is mutually understood. If the volumetric method is used the exact procedure shall be agreed upon by both purchaser and vendor. In case of a disagreement over analysis, the referee shall use the electrolytic method.

Sec. 5C—Determination of Water-Insoluble Matter

Dissolve 50 g of the sample in about 300 ml H_2O, using a 400-ml beaker. Add 2 drops of H_2SO_4, heat on a steam plate, and filter hot through a tared platinum Gooch crucible. Wash thoroughly with hot water, dry at 110°C, cool in a desiccator, and weigh.

Sec. 6C—General Procedure for Sizing Tests

The material used for sizing tests shall be dry. Air drying shall be employed, since heat would drive off water of crystallization. All sizing tests shall be conducted in a dry atmosphere. Standard sieves shall be used and shall not be nested. The material shall be put through one sieve at a time. The test portion shall be placed in the properly selected sieve and shaken in a motor-driven or hand-operated sieve shaker for 5 min. The portion retained on the sieve shall be weighed to the nearest 0.1 g.

Sec. 7C—Other Tests

Tests for impurities or analytical procedures other than those specified in this document may be arranged between the vendor and the purchaser.

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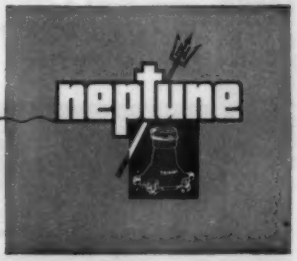

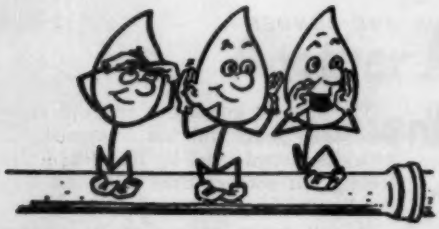

Percolation and Runoff

The 'Happy New Year' of pink elephants and green dragons is obsolete; this year the really "happy" ones are delirious over red space dogs and mauve missiles, and next, the way things are going, they may be chased to the water wagon by fuchsian Venusians or jumping Jupiterians. At any rate, these are wonderful—if sobering—times in which to live and it behooves the water utility field to live up to them, for if the water problems of space travel are solved before we conquer the curse of maximum hour and maximum day, not to mention minimum supply, we may find our best customers blasting off for planets unknown. "Good riddance" isn't the answer either, for a water system without customers pays even less than we're now struggling along on. The answer must be more and more and more and more—more more appreciative customers paying more for more water. That would make for a happy, if not a "happy," new approach to a "Happy New Year."

Meanwhile, for those more inclined to be "happy" than happy, there is a new approach, too, heralded by Roger J. Williams, president of ACS. With his associates at the University of Texas Biochemical Institute, Dr. Williams has found what is believed to be "the biochemical basis of alcoholic craving and, better yet, the way it can be prevented or abolished."

"Happy" or happy, it's a bigger and better water wagon we need!

Not obsolete yet in this Age of Fission, Fusion, and Outer Space is what *Time* magazine recently termed "old-style" water. Recognized as an important ingredient of rocket fuels and as a vital coolant in nuclear reactors, water has just been rediscovered as an effective fire extinguisher by scientists of Great Britain's Windscale nuclear plant—the main British source of plutonium. Unfortunately the rediscovery took a little too long, for, before water was used to put out a uranium fire in a shut-down reactor, so much time had been wasted trying to douse it with carbon dioxide that the radioactive dust created by the fire overtaxed the air filters which capped Windscale's 416-ft chimney and let some of the "hot smoke" loose. Settling on the surrounding countryside—now known as Geiger Gulch—the dust apparently contaminated the grass to a point where it became concentrated in the milk and thyroid glands of cows that grazed there. Although no milk sample was found to be what scientists would term "dangerous," the milk from, first, 150 farms and, later, 1,000 more was dumped as a precaution. Beef cattle sent to market from the area were marked with yellow paint as a signal that their thyroids should be destroyed immediately after slaughter. People not only in the vicinity, but all over Britain, were queasy if not badly

(Continued on page 36 P&R)

(*Continued from page 35 P&R*)

alarmed. And Manchester's 700,000 population, whose water supply comes from the edge of Geiger Gulch, worried that they might be drinking a new style "hot" water.

Actually, although no one seems to have been injured—at least noticeably—the accident does point up some of the less than happy features of our new Age. No matter how unhappy these prospects, however, water utility men will have to act their Age, or, not water, but they will become obsolete!

Kenneth S. Watson, consultant on water management and waste control for General Electric Co., Schenectady, N.Y., has been elected chairman of the Federation of Sewage & Industrial Wastes Assn., succeeding Emil C. Jensen. Mr. Watson has long been active in the water supply and industrial-wastes field, having served on both Incodel and Orsanco, and is a member of the USPHS National Sanitary Engineering Research Advisory Committee.

An exciting new product recently billed in the pages of the *National Truck Drivers Association Journal* may well be worth the consideration of water utility men, particularly those concerned in any way with the use or maintenance of trucks or motor vehicles of any kind. As described in the *NTDA Journal:*

Now, at last! A fabulous solvent with more moisturizing qualities than any other product. It blends better for quicker results. It is free flowing, has instant penetration, ends drying like magic, contains no lacquer, no harsh abrasives. It's deodorized and non-fattening.

Scientific tests show it is eight ways better, so easy to use, so full of natural goodness, so mild.

The moment you try it you will know something wonderful has happened. It provides instant relief for that dehydrated feeling. It soothes tired eyes and ends dry hands.

If you never have used it in your bathtub, you don't know what you're missing. Once you've tried it in the washing machine, you'll never be without it.

Remember to ask for it at your neighborhood service station.

As a cleansing agent it works like magic. Why? Because it contains two miracle ingredients, oxygen and hydrogen, blended according to a secret formula.

Ask for it by name . . . W-A-T-E-R . . . or by its scientific formula, H_2O.

YOU'LL LOVE IT!

Having already publicized some of the stuff in capsule form to promote longevity, we can certainly swear by it. As a matter of fact, we are now almost ready to introduce a new line of AWWA-label food mixers in which it will have the sole role—AWWA Citrus Mix in the 18-oz can, for instance—"just add one 6-oz can of your favorite frozen orange juice for the most delicious citrus juice you have ever tasted." Or AWWA Pancake Base—"just sprinkle in your favorite pancake mix and stir until the mixture reaches desired consistency." Distribution of these products will, of course, be on trucks driven by members of the National Truck Drivers Assn.

Representing AWWA on various committees of the Public Utilities Section, National Safety Council for 1957–58 are the following: W. R. LaDue (Program Committee vice-chairman); T. F. Allen (Engineering Committee vice-chairman; V. A. Appleyard and O. V. Brockway are also on the committee); J. E. Hickman (Membership Committee and Projects

(*Continued on page 38 P&R*)

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...**high quality water!**
...**minimum operating attention!**

"ACCELAPAK" treating plant installation for Fort Myers Beach Waterworks, Inc., Fort Myers Beach, Florida.

Engineering by C. Kenneth S. Dodd, Designing and Consulting Engineer, Sarasota, Florida.

Very compact and efficient, the "ACCELAPAK" plant can easily be installed for new installations or adapted to existing ones. Practically automatic, it requires little attention in operation.

Equipment includes a clarifier or softener, slurry feeder, coagulant feeder, rate-of-flow controller, gravity or pressure filter and other accessories as needed.

SEE YOUR CONSULTING ENGINEER

If you are tolerating inferior water because of obsolete methods or equipment, see your Consulting Engineer. He can give invaluable help in getting the results you want within the budget you can make available.

For detailed information about the "ACCELAPAK" plant write today for Bulletin #1870.

Inquiries are also invited on all other water and waste treating problems for municipalities, institutions and industry.

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THE ONLY COMPANY impartially offering equipment for ALL types of water and waste processing—coagulation, precipitation, sedimentation, filtration, ion exchange, flotation, and biological treatment.

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General Offices • Tucson, Arizona • P.O. Box 5033
Field offices throughout the United States and in foreign countries

(Continued from page 36 P&R)

Committee); and R. J. Faust (special representative).

Philadelphia has joined Los Angeles as a member of the exclusive half-million meter club. Appropriate ceremonies were held recently at the home of Mr. and Mrs. Robert Popow, 4212 N. Reese St., Philadelphia, where meter No. 500,000, bearing a plaque to commemorate the occasion, was installed with the help of the young lady shown in the photograph. The Po-

pows got their meter free, the usual connection charges being waived.

The city's universal metering program was launched in 1953, but did not get into high gear for 2 years owing to litigation. Since 1955, installation has been at the rate of 50,000 a year, with a high of 586 on a day in September 1956. The program will be completed this year, making Philadelphia the fourth major city in the country with universal metering. The others, in addition to Los Angeles, are Cleveland and Detroit.

A waterwise Haligonian is Mayor Leonard A. Kitz, who, last Oct. 17, welcomed the Maritime Branch of the Canadian Section to his city for the group's tenth annual meeting. Thus, it was not of the history of Haligonia —that is to say, Halifax—that he spoke, but of the history of water:

The history of civilization is intertwined with man's ability skillfully to turn water to his use, for we constantly need what Thomas Brown in 1700 called "a cup of cold Adam." And it's not strange that the earliest writings, indeed the Bible itself, have constant allusions to water. Probably one of the most soul-stirring cries for faith is in the analogy of a man requiring water to drink, from *Psalms:*

> My soul thirsteth for Thee,
> My flesh also longeth after Thee,
> In a barren and dry land
> Where no water is.

One of the feats that has staggered modern imagination is the knowledge that the hydraulic engineer had learned his skill in Persia some 4,000 years ago and that in 500 B.C. Athens itself, the wonder of the world for a thousand years, carried water by means of an aqueduct for many miles. So it is not surprising that Rome, when it was leader of the world, should have been a large user of water. The Romans had a water supply system, public baths, pools, fountains, and other amenities, which many parts of Europe have not enjoyed since. At that time the consumption of water was nothing less than 200 gpcd.

One of the glories of Leonardo da Vinci, pundit of the ages, painter, sculptor, aeronautical engineer, was as a designer of the water works for the Pope of the day—nor was that redoubtable figure ever too proud to roll out at night when the plumbing went wrong. Indeed, it is hard to find much derogatory against the men of the water works through his-

(Continued on page 40 P&R)

2.

3.

1. Large illustration shows Singl-use Fiberform ready to be filled.
2. Filling plate and collar simplify pouring concrete into form.
3. Completed meter box barrel.
4. Meter box with cover in place.

4.

FOR ECONOMICAL SETTINGS

1.

Make Your Own

CONCRETE METER BOX BARRELS *with*

FORD *Singl-use Fiberforms*

Water utilities that find vitrified or concrete tile expensive or difficult to obtain, may now make their own barrels for outside meter settings with Ford Singl-use Fiberforms which are inexpensive and easy to use. Forms made for 15", 18" and 20" ID barrels and in lengths of 15", 18" and 24". Use two for deep settings. Send for full information.

FOR BETTER WATER SERVICES

FORD

THE FORD METER BOX COMPANY, INC. Wabash, Indiana

(Continued from page 38 P&R)

tory, except in the expression of "hewers of wood and drawers of water." The "hewers of wood and the drawers of water" were not the hard working souls we think so generally entitled to our pity and sympathy:

Joshua, the great fighter, had just conquered Jericho. Some neighboring tribes were next on the list and decided that they had to do a little bit of quick thinking. They pretended to be ambassadors and represented that they had traveled not from nearby but from a long way off. They put badly worn old sacks upon their asses. They put tattered covers over their wine containers. They covered themselves with patched and worn out garments and used broken sandals. The bread they carried was dry and moldy. They came to Joshua and said: "Look, we've come a long way. When we left we took the bread hot from our oven. Our garments are falling apart." Joshua was taken in and made a treaty of peace. In 3 days, after the pact had been completed, the Israelites realized they had been sold a bill of goods. When they were discovered, the visitors realized they were in a very hot spot, but Joshua decided to honor his word, even though it had been obtained by trickery, and said: "We have sworn unto them by the Lord God of Israel, now therefore we may not touch them. Let them live but let them be hewers of wood and drawers of water unto all the congregation." Maybe some of you are the lineal descendants of drawers of water, and as I am certainly a lineal descendant of Joshua I may have to watch you closely.

Your president is named Gough. He has unhappily denied he is related to the English poet of the same name who wrote so beautifully on water in its many forms:

Everywhere water is a thing of beauty:
Gleaming in the dewdrops;
Singing in the summer rain;
Shining on the ice of the leaves
Till all seem turned to living jewels;
Spreading a golden veil over the setting sun;
Or a white gauze around the midnight moon.

Let me conclude by the old toast which honors water but recognizes that as a beverage it has its rivals:

Here's to old Adam's crystal ale;
Clear, sparkling and divine;
Fair H_2O, long may you flow;
We drink your health—in wine.

What price water? we may ask. What vintage wine?

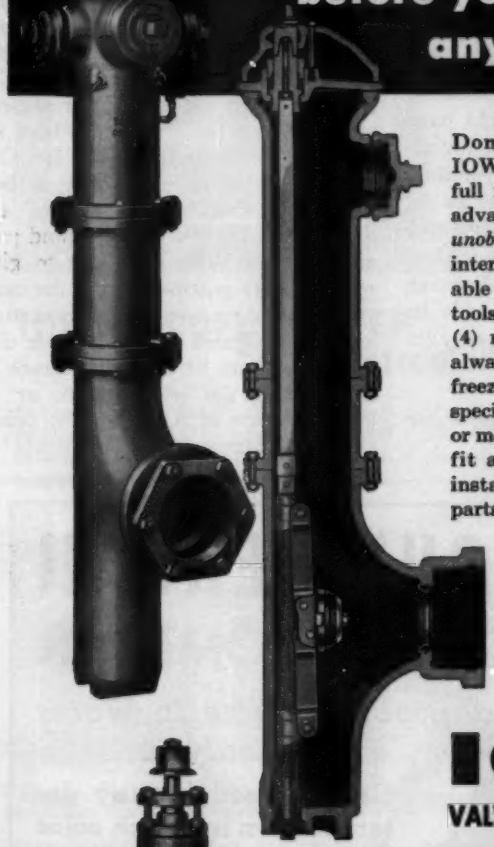
A unique and deadly pollution threat faced residents of the Thamesville, Ont., area recently, when a passenger train smashed a truck loaded with 25,000 lb of copper cyanide dust and sodium cyanide pellets. The poisonous material was scattered along the railroad right-of-way, where a sudden rain or a misguided attempt to wash it down might have contaminated the Thames River water supply of Thamesville and nearby Chatham. Acting quickly, local authorities caused the cyanide to be shoveled up and hauled away to a ditch, where guards stood by until the material, used as a cleaning agent in steel smelting, could be removed permanently. As a precautionary measure, several tons of a chemical neutralizer were spread over Thamesville's streets. The only fatality was a stray dog that, with feline curiosity, licked some of the poison.

Casting votes upon the water system—its development or improvement, seems too often not to stir the voter's interest enough to get him to the polls. Thus, not infrequently, a strong-minded minority will gum up the works—the water works, that is. Not to let this happen in Delta, Iowa, the local Lions Club organized a committee to promote a December election on the establishment of a town water system. And when the vote was in, it was found

(Continued on page 42 P&R)

GET THE INSIDE STORY

before you specify any hydrant!



Don't buy blindly! Only in IOWA hydrants do you get full measure of such practical advantages as: (1) absolutely *unobstructed* waterway; (2) all internal working parts removable through top; (3) no special tools needed for maintenance; (4) no binding or distortion, always easily opened; (5) no freezing; (6) meet all A.W.W.A. specifications; (7) bell, flange or mechanical joint connections fit any existing or planned installation; (8) replacement parts always available.

that's why farsighted city officials choose

IOWA

VALVES AND HYDRANTS

for COMPLETE details, address:

IOWA

VALVE COMPANY

A Subsidiary of James B. Clow & Sons, Inc.

Oskaloosa, Iowa

that every one of Delta's 306 eligible voters had cast his ballot. In congratulating the Lions, we can also congratulate Deltans as a whole, not only for this record exercise of the ballot, but for the way in which it was exercised—to approve a water system by 2 to 1.

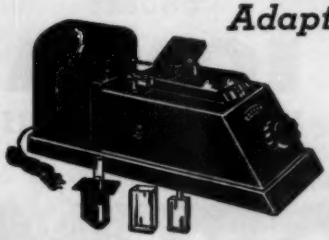
If the fact that water is an important election issue needed to be illustrated, last November's elections would have served that purpose admirably, for almost everywhere, water was running. As a matter of fact, as far away as the tension-ridden Middle East it remained a highlight of a national election campaign—the slogan upon which Premier Adnan Menderes of Turkey rode to easy reelection, promising not only "a school, a road, and a mosque," but also "a faucet for every village."

Voter, voter everywhere, from water do not shrink!

The presidential panting about which we expressed concern last September (P&R p. 88) seems already to have affected the heir presumptive to the highest AWWA office. Certainly the reports that have tunneled back from the Kentucky-Tennessee meeting would seem to indicate that, having heard of the president's embarrassing dissociation from his pants at the Canadian Section last spring, our present vice-president has decided to take no chances. Thus, at Louisville, last October, in addition to wearing a belt and suspenders, Lew Finch was apparently seen to get into a second pair of trousers. With no desire to give space to mere gossip—even of the most authoritative type—we have, nevertheless, felt obligated to repeat these disturbing rumors here on the chance of encouraging the whole truth, or at least as much of it as may be printable. All pantsy fantasy, no doubt!

KLETT SUMMERSON
ELECTRIC PHOTOMETER

Adaptable for Use in Water Analysis

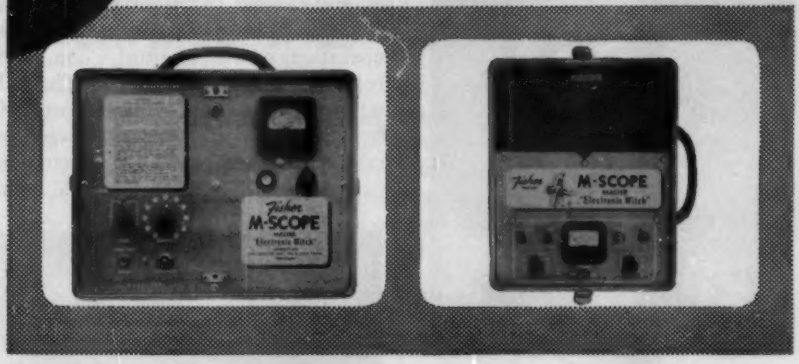


Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.
179 EAST 87th STREET · NEW YORK, N. Y.

New!

TIME-$AVING COMBINATION LEAK DETECTOR-PIPE LOCATOR



THE M-SCOPE MASTER
Electronic Witch Combination

You're looking at the much-talked-about **NEW** M-Scope . . . the only dual-purpose that detects leaks and locates pipe. Its rugged, highly efficient electronic circuit, plus ease of use and portability, make this instrument one of the most welcome contributions to the water works industry.

Quick Facts

For greatest convenience and reliability, the M-Scope MASTER is equipped with a **built-in battery tester** for instant checking of battery condition in the field or elsewhere.

WRITE TODAY FOR SPECIFICATIONS AND PRICE!

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No. 74 & No. 76 California Type Wet Barrel Double Hydrant (for non-freezing weather). INDEPENDENT valves for each outlet; integral curved deflector head; full 6¼" waterway through hydrant body. Greenberg "Cascade" Dry Barrel hydrants are available for freezing climates.

We manufacture a complete line of Industrial and Maritime bronze valves, hydrants, plumbing specialties, plaques, letters and hardware. Write for our catalog.

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Founded 1854

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Phone Exbrook 2-3143
—with offices in principal cities of the United States.

(*Continued from page 42 P&R*)

An engineer's club, for professional and social activities, has been formed by engineering and technical personnel concerned with water supply and other operations of the Hartford, Conn., Metropolitan Dist. Commission. The club, with a membership of more than 100, holds monthly meetings at which films are shown and technical discussions carried on. The members would be interested in hearing from other engineering clubs formed within utilities. Write A. E. Kuras, Secretary, Metropolitan Dist. Engineer's Club, 115 Broad St., Hartford 5, Conn.

Charter officers: seated—Jack Kuras and Frank Saliske; standing—Philip Smith, Albert Helt, and Lawrence Johnson (president).

Kenneth J. Carl has been appointed director of municipal surveys for the National Board of Fire Underwriters,

(*Continued on page 46 P&R*)

Armco Pipe Saves City 21.7% on Industrial Water Line

The city of Cumberland, Maryland, built an 18-inch-diameter water pipe line some 26,500 feet long to supply water for a big new plant. When bids were opened, it was found that *Armco Welded Steel Pipe was 21.7% below* the lowest of three bids submitted on competitive pipe.

Most of the Armco Pipe was supplied in 50-foot sections. This meant fewer sections to haul and handle—fewer field joints. The contractor completed the job ahead of schedule.

For any water line you will find that Armco Steel Pipe offers many advantages. Diameters range from 6 to 36 inches; wall thicknesses from 9/64- to ½-inch. Coatings meet AWWA specifications; a spun enamel lining prevents tuberculation.

Write for complete data on Armco Pipe and Armco Gates for water works construction. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 4057 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario.

This 50-foot length of Armco Steel Pipe is part of a 5-mile water line to an industrial plant at Cumberland, Maryland.

City Engineer: Charles R. Nuzum • **Consulting Engineer:** Robert T. Regester, Baltimore • **Special Design Engineer:** W. E. Piper

Contractor: The Cumberland Contracting Co.

ARMCO WELDED STEEL PIPE

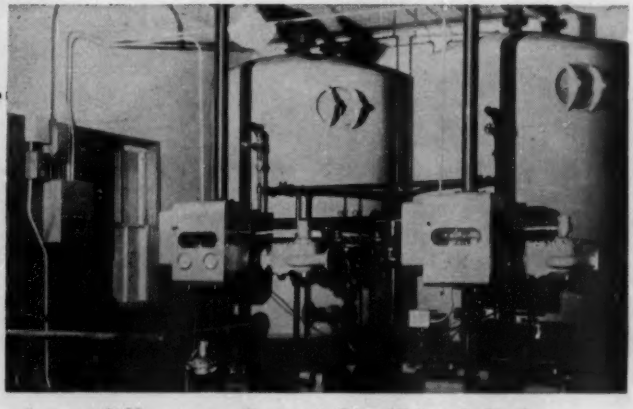
ARMCO®

(*Continued from page 44 P&R*)

with Robert A. Young as his special assistant. George J. Robinson has been named senior assistant chief engineer, and George P. Stahl assistant chief engineer, in the Chicago office of NBFU. Mr. Carl was formerly a supervisory engineer in the New York office, and Mr. Robinson was assistant chief engineer. Mr. Stahl and Mr. Young were engineers in the Chicago office.

The stenographic pool is fast moving to the backyard—the stenographer's backyard, that is, as the day when only the "filthy" rich could splash about in their own swimming pools has whizzed by so fast we didn't even see it passing. Last year no less than 30,000 home swimming—and we do mean "swimming," not wading—pools were built; this year the estimate is 45,000; and by 1959 it is expected that there will be at least 150,000 home pools. The impact of all this backyard beaching has already been felt in other areas than public water supply. Community councils, for instance, have had to make new fencing laws to protect their citizens against injury or death, and insurance companies have developed new provisions to protect pool owners against suit. Meanwhile, health departments have also acquired a new problem in attempting to set some standards for maintaining the safety of the pool waters; and the chore of instructing Mrs. Jones on how many tablespoons of chlorine to add to her so-big pool has already been a headache in more than one community.

(*Continued on page 48 P&R*)



Iron and Manganese Removal Plus Water Softening . . .
Automatically by Ion-Exchange using Invercarb C-110

Low in cost—efficient in operation. Send for Particulars.

DAY SERVICE

HUNGERFORD & TERRY, INC.

CLAYTON 5, NEW JERSEY

For Houston's new 50 mgd plant . . .

Freese, Nichols & Turner, Consulting Engineers, specified the most modern, master filter control system.

This system, for the City of Houston's recently completed $5,000,000 modern water purification plant that is now in service, must deliver top filter performance: maintain exact total flow despite changes in head in 8 filters; precisely measure flow rate, head loss; carefully control wash rates to protect beds; transmit all vital data to *one central control point*—with no lag, no hunting, no inaccuracies.

To meet these rigid requirements, Simplex flow controllers and instrumentation were selected. For dependable pipe-gallery operation, Simplex Laminair® units *pneumatically* transmit data to operating tables. For complete control of all the wide spread operating elements, Simplex Orthoflow® units *electrically* transmit data to one central point—instantly, accurately.

Your plant may achieve automated operation with minimum changes in present instruments and controls. Write for information. Simplex Valve & Meter Company, Dept. JA-1, 7 E. Orange Street, Lancaster, Pa.

SIMPLEX®
VALVE AND METER COMPANY

(Continued from page 46 P&R)

But it is the water utility that can look forward to the biggest problems, as not only the pool owners, but the utilities themselves, find that present piping and meters are inadequate to carry the extra load of supplying pools that hold thousands of gallons of water. And with maximum use to be expected in summer on top of peak demand, the water business is likely to get better than most utilities can stand. Even if new housing developments which—like some of the medium-priced ones on the West Coast, already do—install pools as standard equipment are required to provide adequate piping, there are bound to be headaches in old backyards. One happy development, however, is a "revolutionary new device"—"an epoch-making development"—that promises to make the pool business a good, steady, year-round one. That is the "Pool House," a balloon-like, dome-shaped air structure, which when blown up around the pool (see cut) makes it usable in the severest winter weather.

As far as the water utility is concerned, of course, there's no pool like a cold—well, cold-weather—pool!

Developed by the Hoosier Tarpaulin & Canvas Goods Co. of Indianapolis, this vinyl-coated nylon structure is provided with a heating unit in combination with an electrically driven blower that keeps the air inside fresh and warm. A pool water heater is optional. Cost is about $1.50 per square foot of ground covered.

(Continued on page 50 P&R)

Roberts Filter *means...*

MUNICIPAL WATER PURIFICATION

The combined capacity of Roberts-equipped filtration plants is well over 5 billion gallons (5,000,000,000) per day. Regardless of the size of the plant or the nature of the filtration problem, Roberts Filter can be depended upon for equipment that is reliable in years of service.

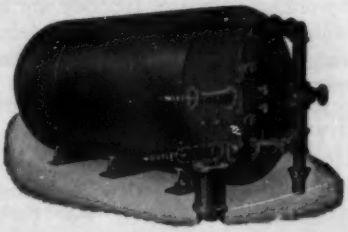
INDUSTRIAL WATER RECTIFICATION

Water treatment has long been a specialty of Roberts Filter. Zeolite water softeners are guaranteed to meet all requirements for which recommended, and are available in a wide range of capacities. Roberts water conditioning equipment is widely used to control precisely the desired chemical content of water for industrial use.

SWIMMING POOL RECIRCULATING SYSTEMS

The combination of thoroughly clarified water and efficient recirculation are features for which Roberts pools are famous. Systems for both outdoor and indoor pools are designed and installed by men long experienced in the conditions peculiar to a successful swimming pool installation.

PRESSURE FILTERS



Closed pressure filters have wide usage where gravity filters are not justified. Roberts vertical filters are available in standard types from 12" to 96" diameter; horizontal pressure filters are all 8'0" in diameter and in varying lengths from 10'0" to 25'0".

When you think of good water—think of Roberts Filter

MECHANICAL EQUIPMENT

Roberts Filter

Manufacturing Company • Darby, Penna.

(*Continued from page 48 P&R*)

Howard E. Moses, director of the Div. of Sanitary Engineering, State Dept. of Health, Harrisburg, Pa., and a pioneer in clean-streams programs, died Nov. 13, 1957. He was 82. Born in 1875 in Muhlenberg, Pa., he was educated at Dickinson College, the University of Maryland, and Johns Hopkins. He came to Harrisburg in 1899 as a mechanical engineer for a foundry and machine works there. In 1908 he joined the State Dept. of Health as an assistant engineer, becoming chief of water works and sewerage in 1916, assistant chief engineer in 1922, and chief sanitary engineer, as well as acting director of the Bureau of Engineering, in 1937. In 1942 he was appointed director of the Div. (then Bureau) of Sanitary Engineering, the position he held at the time of his death. From October 1953 to June 1954 he also served as acting director of environmental health services. Despite the multitude of his official duties, he found time to engage actively in the work of Orsanco, Incodel, the Interstate Commission on the Potomac River Basin, and the Great Lakes–Upper Mississippi River Board of Engineers.

A Life Member of AWWA (joined in 1922), he was a past-chairman of the Pennsylvania Section, on whose nomination he received the Fuller Award. Mr. Moses participated in the formation of FSIWA, serving as its secretary for 13 years and being named an honorary member. He also belonged to ASCE (life member), CSSE, Pennsylvania Water Works Operators' Assn. (president), Pennsylvania Sewage & Industrial Wastes Assn. (president), and Engineers Society of Pennsylvania (president and secretary).

Oliver J. Ripple, president of the consulting engineer firm of Ripple & Howe, Denver, Colo., died Oct. 24, 1957, at the age of 71. Born in Kansas in 1886, he was graduated from Colorado State University in 1909. From 1924 to 1945 he served as superintendent of filtration at Denver, leaving in the latter year to become a partner in the firm bearing his name. He had been president since 1955.

An AWWA member since 1930, he received the Fuller Award as a nominee of the Rocky Mountain Section, which he served as chairman and director. He also belonged to NSPE and the Colorado Society of Engineers.

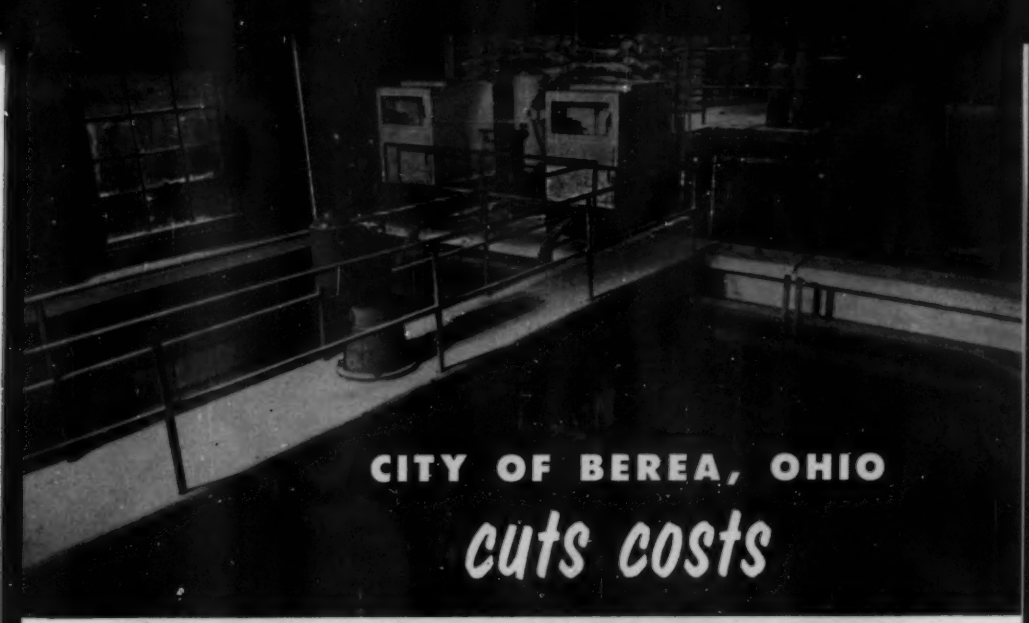
Employment Information

Classified ads will be accepted only for "Positions Available" or "Positions Wanted." Rate: $1.50 per line (minimum $5.00), payable before publication. Deadline for ad copy: first of month prior to month of publication desired. To place ad, obtain "Classified Ad Authorization Form" from: Classified Ad Dept., Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

Positions Available

SUPERINTENDENT OF UTILITIES

Wanted by the City of Ann Arbor to take charge of the management, maintenance, and operation of the city water works and water system. Modern plant and equipment in excellent condition—total assets, $4,787,190. Major expansion program underway. Require experienced engineer. Salary open; includes all fringe benefits. Write Guy C. Larcom, Jr., City Administrator, City Hall, Ann Arbor, Michigan, for full information.



CITY OF BEREA, OHIO *cuts costs*

New Cochrane SOLIDS-CONTACT REACTOR *combines*

mixing, precipitation, sludge concentration, clarification & softening

The relatively hard, turbid Rocky River supply for the city of Berea, Ohio, is quickly reduced in hardness to approximately 3.5 gr/gal and to a turbidity of less than 10 ppm by the Cochrane Solids-Contact Reactor shown above. An existing concrete basin 28′ square x 15′ deep was modernized by conversion to the Solids-Contact type. Using hydrated lime, soda ash and alum, the Reactor treats over 2,000,000 gpd at surprisingly low cost.

Because the design of the Cochrane Reactor provides higher quality treated water faster, in less space, with minimum chemicals, their use has grown tremendously for municipal applications. High slurry strength in the reaction zone speeds precipitation—there is very little waste water. Automatic desludging saves time and labor. In addition to softening and clarification, Cochrane Reactors remove color, taste, odor; reduce alkalinity, silica, fluorides, etc.

Cochrane's background in water conditioning makes possible the installation of complete systems under a single responsibility for continued, consistent performance. Write for Publication 5001-A and case history reprints.

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Representatives in 30 principal cities in U.S.; Toronto, Canada; Paris, France; Mexico City, Mexico; La Spezia, Italy; Havana, Cuba; Caracas, Venezuela; San Juan, Puerto Rico; Honolulu, Hawaii; Malmo, Sweden; Santiago, Chile. Pottstown Metal Products Division—Custom built carbon steel and alloy products.

Cochrane also manufactures circular reactors

Demineralizers • Hot Process Softeners • Hot Zeolite Softeners • Dealkalizers • Reactors
Deaerators • Continuous Blowoff • Condensate Return Systems • Specialties

Correspondence

Semasiological Sympathy

To the Editor:

Down with "water superintendent." Amen, and amen!

The leadoff paragraph in the October 1957 P&R section has aroused within me an oppugnant semasiology hitherto buried in the morass of custom.

Why the managing head of a city's most valuable asset is relegated to a seat below the salt by appending such a title to his position is beyond understanding, although there is little doubt that his meek acceptance of the belittling appellation keeps him there. It may be that the denotation of the word is considered to be sufficiently descriptive of his position. However, if the connotation of the word does not escape those who apply it and his position is perceived as being one of managerial responsibility and authority, carrying with it an obligation to conduct affairs with skill and economy by commanding respect and confidence, then he should be given the correct title of manager or director.

As a superintendent, the managing head of a water utility cannot fail to be accorded an inferior position by others. For instance, when he attends, say, a civic affair in company with the telephone company manager, the power company vice-president, the gas company district manager, and presidents and officers of other businesses in the community, he is demoted, unconsciously or not, to a lesser position, despite the quality of his professional rank. As you stated, this misapplied nomenclature is one of the principal factors contributing to the low status of our water utility executives.

John Murdoch's Task Group 2220 M is currently engaged in developing a rating scale for water utilities. Included in it will be a means by which the degree of executive status can be determined. Then, superintendents in name but managers in fact will receive encouragement when demanding upgraded titles.

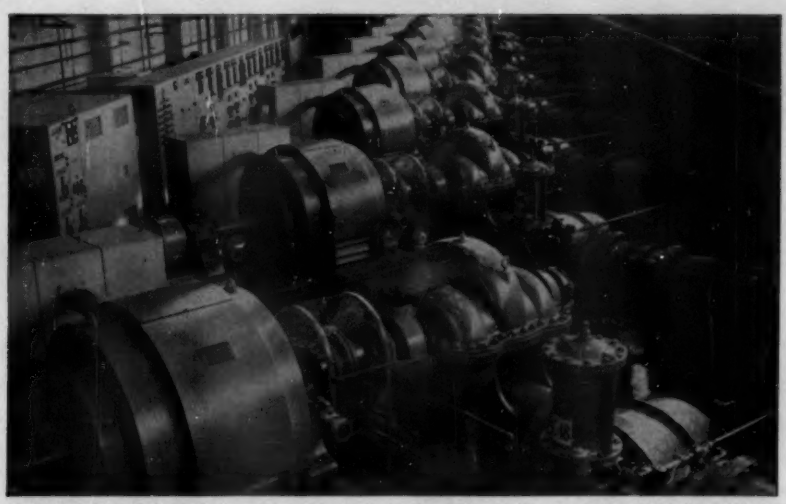
Meanwhile, it's high time we did something about "water superintendent." Let's add semasiology to our public relating.

HENRY WILKENS JR.

Houston, Tex.
Nov. 11, 1957

Anyone else oppugnacious?—ED.

ARREST
RED WATER DUE TO IRON IN WATER AND IRON PICKUP IN THE MAINS.
STAINING OF PLUMBING FIXTURES IN CUSTOMER RESIDENCES.
EXCESSIVE MAINTENANCE ON WATER METERS, PIPES AND VALVES DUE TO BUILD UP OF DEPOSITS IN THE WATER SYSTEM, WITH
INDUSTRIAL CHEMICALS FORMULA 114 OR 115
HIGH PURITY, HIGH MOLECULAR WEIGHT MATERIAL FOR THE ULTIMATE IN WATER TREATMENT. EASY APPLICATION POSSIBLE WITH NON TOXIC MATERIAL SAFE FOR USE IN POTABLE WATERS WHICH
STOPS
CUSTOMER COMPLAINTS.
FOR INFORMATION ON COMPLETE WATER TREATMENT WRITE TO
INDUSTRIAL CHEMICALS, INC. SOUTH BEND 14, IND.



Eight 24" SMS-Rotovalves are used for pump check service at the Secondary Pumping Station of the U. S. Air Force's Arnold Engineering Development Center in Tullahoma, Tenn.* Installed on 25,000 GPM pumping units, each hydraulically-operated Rotovalve has independent timing control for opening and closing, and a by-pass fast closure device for shut down in the event of power failure. Four more 24" Rotovalves perform similar service at the Primary Pumping Station.

CLOSE CONTROL OF TIMING MAKES SMS-ROTOVALVES CHOICE AT TULLAHOMA

When laying out the cooling water facilities at Tullahoma, Robert and Company Associates of Atlanta, Consulting Engineers under contract with the Tullahoma District, Corps of Engineers, U. S. Army, selected SMS-Rotovalves for pump check service. Close, positive control of valve opening and closing time that minimizes water hammer as pumps are cut in and out of the system made Rotovalves the first choice. Their rugged design and record for low maintenance cost were also important for this severe service.

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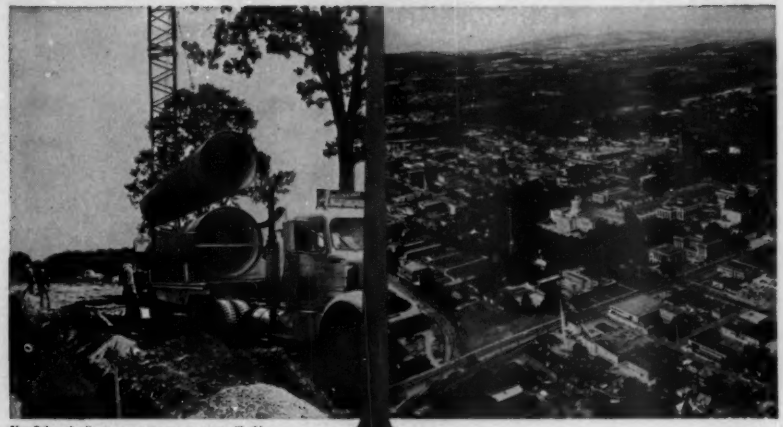

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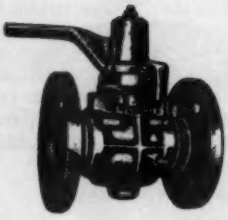

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Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

DAMS & RESERVOIRS

The Use of Statistics in Reservoir Operations. V. A. KOELZER. Proc. Am. Soc. Civil Engrs., 82, HY3, Paper No. 1008 ('56). Author demonstrates use of statistical procedures to evaluate water supply probabilities and probability of occurrence of extremes of water supply for formulation of plans for reservoir operation. Procedures are applied to planning of reservoir operational schedules in Colorado and Platte river basins in midwest USA. Graphical and tabular illustrations included.—*WPA*

The Role of Biochemical Processes in the Phosphorus Cycle in Reservoirs. M. V. MOSEVICH & V. M. DANILEVICH. Izvest. Vsesoyuz. Nauch.-Issledovatel. Inst. Ozernog. i Rechnogo Rybnogo Khoz. (USSR), 36: 149–64 ('55). At almost all lake bottoms investigated (near Don River mostly) bacteria are found which transform low soly. P into sol. P; bact. count is 11,000/g soil. Amt. of P actually solubilized depends upon activity of these bacteria, and ones influencing N cycle and ones participating in P cycle are not independent of each other. As rule, P will be easily solubilized if much org. matter is found at lake bottom. In lab. aquarium, where P and N compds. could be added to H_2O singly or in combination, it was found that presence of Fe^{+++} will accelerate solubilization of P, and addn. of water high in humins would increase activity of ammonifying and of denitrifying bacteria. Introduction of phosphorite meal and manure would bring about increase of rate of all these biochem. processes, plus anaerobic fixation of N. Greatest increase of rate is brought about if agricultural soil is introduced into such aquarium.—*CA*

The Problem of Reservoir Capacity for Long-Term Storage. A. FATHY & A. S. SHUKRY. Proc. Am. Soc. Civil Engrs., 82, HY5, Paper No. 1082 ('56). New theoretical basis for dtn. of capac. needed in long-term storage reservoirs to guarantee given draft is presented; deviations in arithmetic mean of groups of hydrological observations are utilized instead of deviation of single observation as used in Hurst's proposed soln. to problem. Examples are given in which treatment is applied to cases where draft is equal to or less than mean, or is varied, from year to year, with particular reference to proposed reservoir construction on upper Nile.—*WPA*

The Most Important Changes Taking Place in Natural and Artificial Reservoirs for Drinking Water. J. GRIM. Gas- u. Wasserfach (Ger.), 98:234 ('57). With exception of some of deeper lakes, most go through summer and winter stagnation periods, and spring and fall periods when water is thoroughly mixed and dissolved material content becomes uniform. Many artificial reservoirs have no stagnation period. Depth at which most satisfactory water can be secured varies with season, and several outlets or adjustable outlet should be provided. Direct flow from streams (usually of poorer bacteriol. character than balance of reservoir) should be avoided by use of intermediate reservoirs, riffles, dams, etc., so that water is at same temp. as that of reservoir, as variable temp. during day and night may cause mixt. of this inflowing water throughout body of water in reservoir. Contaminating materials, especially nutrients for algae, etc., should be kept out of water as completely as possible. Where stream flow must be maintained, water should be taken from level at which it is of poorest qual. It is desirable to drain off lowest water level (highest in nutrients and often in Fe and Mn) in early spring and in fall; turbulence must be avoided when this is done.—*CA*

(Continued on page 64 P&R)

Aerial view of the R. C. Harris Plant of The Municipality of Metropolitan Toronto; R. L. Clark—Commissioner of Works. Photograph was taken during construction of plant's additional facilities.

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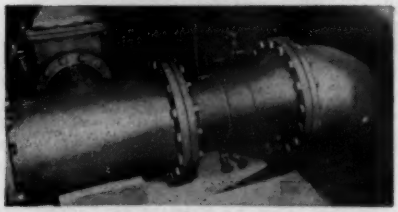

Actual installation of a 16" Flow Tube for REVERSE FLOW. Note fittings (elbow and tee) are bolted directly to flanges of Flow Tube.

Gentile Flow Tubes can be furnished with or without suitable secondary indicating, recording, or totalizing instruments.

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AUTOMATIC VALVES • CONTROL VALVES
SAFETY VALVES • FLOW TUBES

(*Continued from page 62 P&R*)

The Engineering Design of Municipal Water Supply Reservoirs. V. H. Rosebraugh. Kansas State Coll. Eng. Exp. Sta. Bul. No. 80 (Aug. 15, 1956). Drought that has occurred in Kan. since 1951 has led to this study to det. inadequacies of reservoir water supplies and develop design criteria to guide future design. Because very little general design data are available, min. design characteristics were detd. on empirical basis by analyzing existing supplies. Report gives factors used for detg. following results: Min. design values for storage vols. and drainage area were detd. as 125,000 adjusted gal and 2.25 adjusted acres/person using water. Report emphasizes that above figures are not to be used blindly but only as guides for eng. judgment.—*PHEA*

DISINFECTION

Contribution to the Problem of Ultraviolet Disinfection of Water. W. Zimmerman. Z. Hyg. Infektionskrankh. (Ger.), 143:91 ('56). Results are given showing effect of treatment of small water supply with ultraviolet rays over 1 yr. Untreated water had very high bact. count and a *coli* titre of 1 cc. Water was very hard, neutral in reaction, and contained normal amts. of org. matter and salts and 0.3 mg Fe/l. 2 ultraviolet mercury low-pressure lamps irradiated channel in which water flowed in layer 3–4 cm deep at rate of 18 cu m/hr. After irradiation, water was bacteriologically satisfactory throughout distr. system.—*WPA*

Experience With "Micropur" in the Disinfection of Wells After Pollution by Flood Water. W. Oberzill. Z. Hyg. Infektionskrankh. (Ger.), 143:62 ('56). Severe flooding in Austria in summer of 1954 resulted in polln. of large number of wells. Expts. are described on use of "Micropur," silver preparation, along with equal wt. of peroxide compd. sold under name "Wirkstoff." Lab. expts. showed that *Bact. coli* added to natural water in amts. of about 1,000/cc were reduced in few hrs below limit of detection. Addition of "Wirkstoff" accelerated and intensified action. Reduction in temp. increased time required. Increase in poln. decreased effect. Time required was longer if concn. of bacteria was greater. *Coli* strains from unpold. water

(*Continued on page 66 P&R*)

Thinking about soft water for your community?

Reliable sources predict at least a 50% increase in the number of water-softening units during the next 5 years. As a service to the growing number of soft-water users, International Salt Company has prepared a series of articles on the efficient use of salt in regenerating zeolite and/or base-exchange resins. Here's No. 11.

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Portable Conveyor System. A power-operated belt conveyor of suitable length is placed inside the car door, and salt is then shoveled onto it. A good conveyor for most needs is generally about 16 to 18 feet long and capable of moving salt up a 30° slope. With a conveyor, one 40-ton car can be unloaded in about 12 to 14 man-hours—a 19% saving in time over straight manpower.

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Automatic Power Shovel. This device consists of a large, power-operated scraper blade mounted on a cable—and is one of today's most popular devices for unloading bulk salt. The scraper is moved toward the end of the car. As soon as this motion stops, a power winch takes hold, to drag the scraper toward the car door. One man can unload a 40-ton car in 2 or 3 hours by this unique method.

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INTERNATIONAL SALT CO., INC.

SCRANTON 2, PA.

(*Continued from page 64 P&R*)

were more resistant than strains of faecal origin. Water treated with "Micropur" retained its bactericidal action for some time. Expts. were then made on 25 wells. 3 methods of treatment were investigated. 10 wells were treated on 1 day with about 100 g "Micropur"/cu m and on next with about 50 g; 6 wells were treated with 1 addition of 1,000 g/cu m; other wells, after preliminary treatment with 100 and 50 g/cu m, as in first series, were treated weekly with 10 g. Equal ws. of "Wirkstoff" were used in all cases. Results, even in unfavorable conditions, showed definite disinfecting effect. Where poln., as in many of wells affected by flood water, was nonrecurrent, 1 treatment gave good results but for recurrent poln. repeated treatment was necessary to maintain effective concn. of silver ions in water; amt. added and frequency of addn. must be related to withdrawal. Dosages recommended by makers (100 g/cu m for initial treatment and 10 g/cu m for weekly subsequent treatment) appear from expts. to be min. effective amts. Process of intermittent treatment with silver preparation such as "Micropur" is recommened for simplicity and ease of operation.—*WPA*

Experimental Determination of the Conditions Necessary for the Purification of Drinking Water by Means of Silver Preparations. W. Oberzill. Arch. Hyg. u. Bakteriol., 141:217 ('57). Silver preparations have been used for considerable time for disinfection of drinking water and method has considerable advantages for treatment of well waters in country districts. Nevertheless, there have been adverse accounts about efficacy of disinfection of water by silver. This paper describes results of extensive series of expts. on disinfection of artificially pold. water. Factors which influence silver disinfection and which were studied included: initial numbers of polg. organisms, variations in dosage of silver, differences in phys. and chem. compn. of water, effects of temp. on rate of disinfection and sensitivity of different polg. organisms to silver. Results of investigations are described with help of figs., and are fully discussed. It is maintained that unsatisfactory results of disinfection of drinking water by silver are attributable to use of method under inappropriate conditions.—*BH*

Modern Processes of Disinfection of Water in Relation to Corrosion. L. W. Haase. Vom Wasser, 22:420 ('55). All normally used processes of disinfection of water have in common formation of atomic oxygen. Author gives and discusses chem. reactions of number of oxygen and chlorine compds. in water and describes investigations into their action on different metals. Method of action of acids and of atomic oxygen is described. Results lead to conclusion that in practical use of disinfection processes, formation of effective free chlorine must be avoided and that compds. with atomic oxygen as effective agent are to be preferred. Effects of oxygen in water pipes of iron, galvanized iron, aluminium, brass, and copper are considered.—*WPA*

A Method of Treating Water With Chlorine Dioxide Without the Use of Chlorine. E. A. Snow. Sanitalk, 5:21 ('56). Author

(*Continued on page 68 P&R*)

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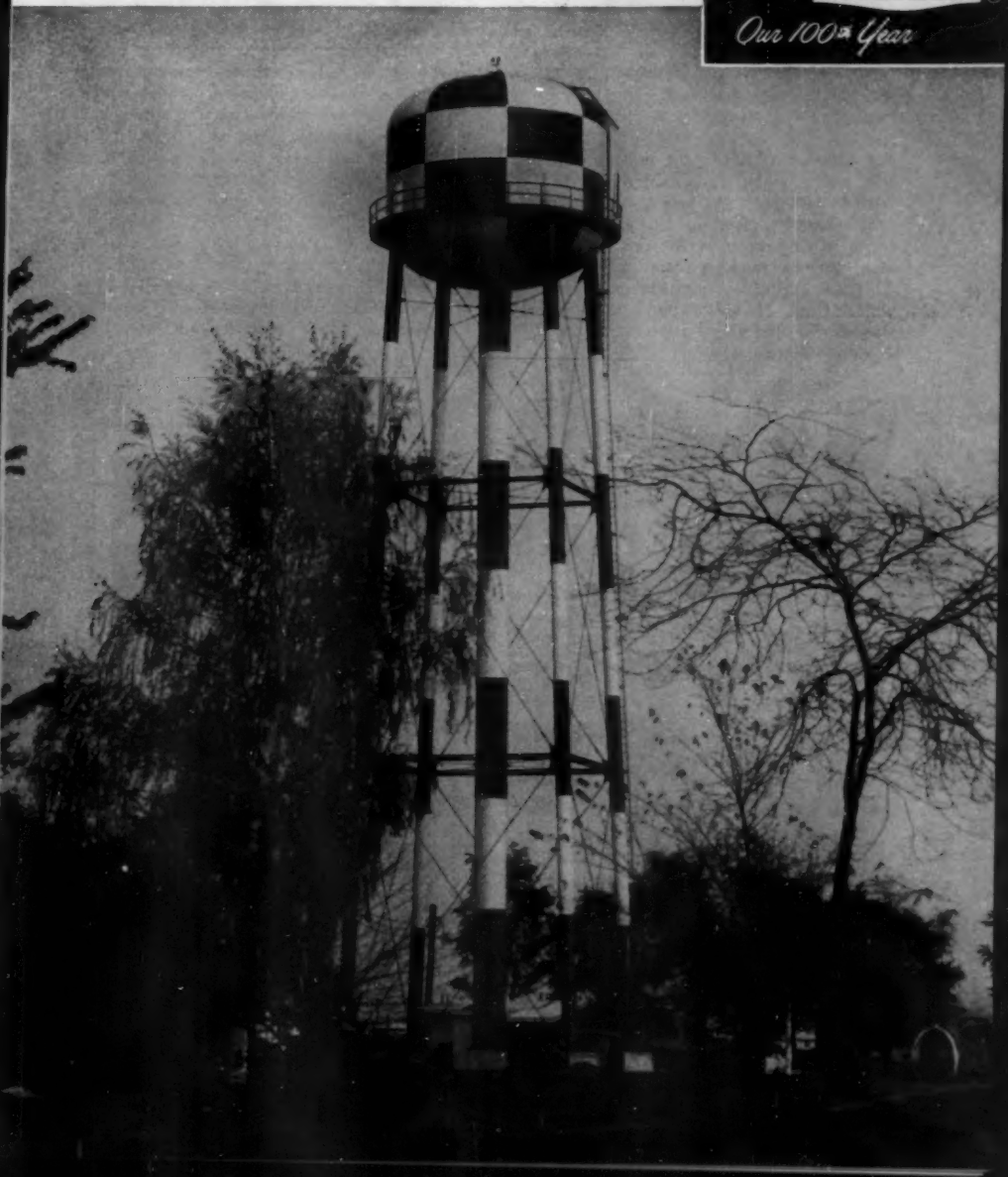

(*Continued from page 66 P&R*)

describes investigations which have been carried out in attempt to treat water with chlorine dioxide without using chlorine. Amherst, Mass., water, which is generally completely free from coliform bacteria but at times contains considerable color and occasional turbidity, was used in preliminary expts.; sodium chlorite and ferrous sulfate were added together to water, sample was mixed and allowed to stand for 30 min. Lime was then added to give desired pH value and water was filtered through exptl. sand filters. Results showed that use of chlorite and ferrous sulfate did help to reduce color. 6 parallel expts. were then carried out using varying amts. of sodium chlorite, ferrous sulfate, alum, and lime or soda ash, water under examination having been seeded with dil. suspension of *Escherichia coli*. Results, given in tables, showed that coliform organisms were completely absent after periods ranging from 2 hr to 48 hr. This was repeated using Amherst water and water from Hayden's pond and again it was shown that there were no coliform organisms even after 20 min, although few sporeforming bacteria were found.—*WPA*

Quantitative Studies on the Reaction of Chlorine with Bacteria in Water Disinfection. An Experimental Investigation with Radioactive Chlorine Cl^{36}. L. FRIBERG. Acta Pathol. et Microbiol. Scand., **38**:135 ('56). Quant. study of process of chlorine-bacteria reactions in water distinfection. Known amt. of washed bacteria was added to chlorine-demand-free water contg. measured amts. of radioactive chloride and radioactive, free available chlorine. Radioactivity of water was measured prior and subsequent to addn. of bacteria. Amt. of chlorine combining with and being adsorbed on bacteria was detd. After similar calcns. for chloride, amt. of free available chlorine combining with bacteria was computed. *Escherichia coli* and *Staphylococcus aureus* were used as test bacteria, at water temp. 20°C and pH 6.5 and 8.2, respectively. On avg., 10–25% of free available chlorine used was found in bacteria after 5-min exposure.—*PHEA*

(*Continued on page 70 P&R*)

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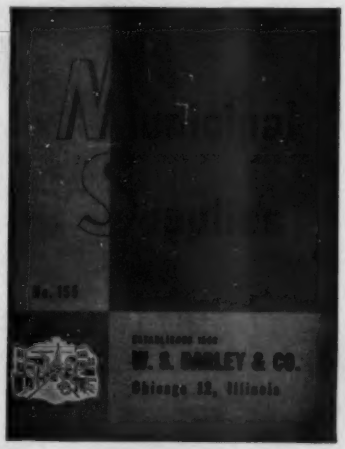

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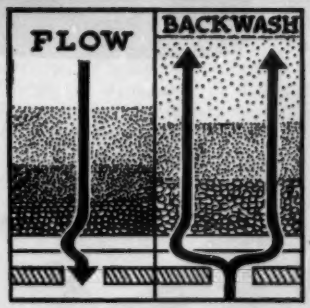

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FILTRATION EQUIPMENT CORPORATION
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(*Continued from page 68 P&R*)

The Disinfection of Water by Ultraviolet Rays. E.-V. Rouir. Bul. Mens. Centre Belge Etude et Document. Eaux (Belg.), 6 ('55). App. for use in disinfecting water by ultraviolet radiation from low-pressure mercury lamp has been developed after tests were conducted to det. the penetrative power of ultraviolet light at 2537 Å in various waters, and effect of lamp wall temp. on emission of ultraviolet rays. As optimum lamp wall temp. was found to be 35°–40°C, it was necessary to isolate mercury lamp from water by surrounding it with tube of quartz or glass transparent to rays of 2537 Å. Apparatus was enclosed in cylinder of aluminium which has good reflective power for ultraviolet light. Efficiency of this apparatus was compared with that of 2 others containing 1 mercury lamp and 3 mercury lamps respectively, all in direct contact with water to be disinfected. Test water was inoculated with coliform bacteria and, after treatment by mercury lamps, was bacteriologically examined using 3 different types of liquid media and solid medium. Results of all expts. are given in graphs and tables, and diagrams and photographs of apparatus are included.—*WPA*

Disinfection of Drinking Water With Hydrochloric Acid. M. Kristensen & K. Skadhauge. Acta Pathol. Microbiol. Scand. (Den.), 40:216 ('57). Salmonella and dysentery and cholera bacteria in drinking water can be destroyed by adding hydrochloric acid to give concn. of 0.06N. After 10 min, acid is neutralized by addn. of 5 g sodium bicarbonate/l. This method is not reliable for destruction of poliomyelitis and other viruses or of amoebic dysentery cysts.—*WPA*

POLLUTION CONTROL

Toxicity Considerations in Pollution Control. J. T. Garrett. Ind. Wastes, 2:17 ('57). Author considers toxic effects to man and animals which may result from continued consumption of water contamd. with industrial waste waters. Certain chronic toxicity data are available, and should be obtained when studying effect of pollutants on human or aquatic life. Data are available on effects of many chem. materials on aquatic organisms. Author gives results, shown in tables, of tests carried out

(*Continued on page 72 P&R*)

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Typical vertical installation of Wheeler-Economy Single Stage, Double Suction Pump. These High-Head Pumps, usually installed horizontally, can easily be mounted vertically, with a 50% saving in floor space. Motor here is located directly over Pump, but it could have been mounted on a floor some distance above Pump.

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(*Continued from page 70 P&R*)

on toxicity of hydrogen cyanide, acrylonitrile, and allied substances, and various chlorinated compds., such as 1,2-dichloroethane, to the pinperch, *Lagodon rhomeboides.*—*WPA*

Protection of Water-Supplies From Pollution. H.-J. KNOBLAUCH. Literaturber. Wasser Abwasser Luft u. Boden, **5**:3 ('56). Author describes methods of preventing poln. of water in distr. systems through connections with drainage systems.—*WPA*

Increased Protection for Water Supplies by Legislation. H. BAUER. Neue Deliwa, **4**:113 ('56). Author discusses requirements of new legislation with regard to water supply and deals with methods of supervision of works and protected drainage areas and difficulties of small works.—*WPA*

Protective Areas for Water Supply as a Factor in Planning. F. VINCK. Bauamt u. Gemeindebau, **29**:68 ('56). Author discusses application of regulations for protective areas for water supplies to insertion of green belts in planning of towns. He discusses effects of length of travel, period of retention and depth of filter below surface on condition of ground water.—*WPA*

The Health Department's Role in New York Harbor Pollution Control. H. ROMER. Sewage & Ind. Wastes, **28**:1495 ('56). Author discusses role of health department in coordinating efforts of various depts. and agencies concerned with planning of poln. control projects, and illustrates this by reference to studies of poln. in Jamaica Bay and New York Bay in New York Harbor. In appendices are given Interstate Sanitation Commission's classification of metropolitan New York tidal waters, and New York City Board of Health's classification for bathing waters.—*WPA*

The Law and Pollution of Water by Industrial Plants. Brit. Chem. Eng., **1**:374 ('56). Public awareness of pold. state of rivers in Gt. Br. has led to statutory legis-

(*Continued on page 74 P&R*)

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(*Continued from page 72 P&R*)

ladon, culminating in Rivers (Prevention of Pollution) Act, 1951, which empowers river boards to prescribe and enforce compliance with, standards for effluents discharged to rivers. Parties causing poln. of rivers are also subject to actions at common law at instance of riparian owners. To emphasize strictness of common law criterion of poln. 2 cases are described in which injunctions were granted against private industries and public authorities for poln. caused by discharge of trade wastes, heated effluents, and sewage into rivers.—*WPA*

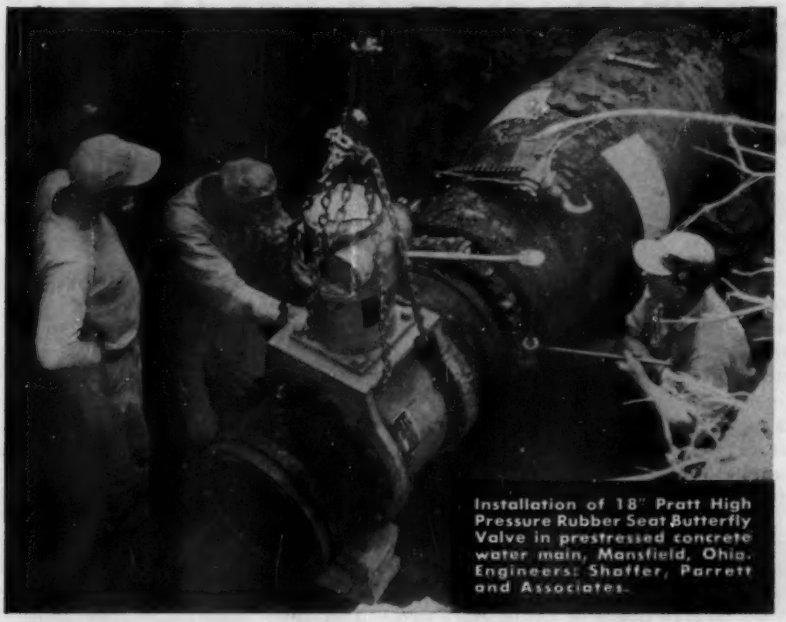
Methods for the Timely Recognition of Widespread Pollution of Ground Water. K. SCHLINKER. Wasserwirtsch.-wassertech., 6:137 ('56). Signs of deterioration in qual. of ground water supply of industrial town led to investigations by borings. Sources of poln. were found to be unsewered community and dumping ground. From rate of flow of ground water it was calcd. that massive poln. would not reach intake for 4–6 yrs.—*WPA*

POLLUTION CONTROL

Importance and Use of Instantaneous Electrochemical Measurements of Oxygen in the Control of Polluted Waters. F. TODT. Quarterly Bul., Centre Belge Etude et Document. Eaux, 36:70 ('57). Design and use of equip. for instantaneous electrochem. equip. for measurement of oxygen dissolved in water is described.—*PHEA*

Preventing Deterioration of Streams in Densely Populated Districts. W. MULLER. Gas- u. Wasserfach (Ger.), 97:944 ('56). Author discusses sources of poln. of streams in populated districts, influence of density of pop., and methods of calcg. permissible sewage load in relation to stream flow and to self-purifying power of stream. Inadequacy of even complete biol. treatment of sewage to protect stream in densely populated regions and methods of increasing self-purifying power of streams are discussed.—*WPA*

Protection of Water Supply and Waters From Radioactive Pollution. B. DIETERICH. Mitt. Deut. Gewasserschutz (Ger.), No. 8/9 ('56). Author deals briefly with effects of poln. by radioactivity, German legislation for protection of surface and ground waters, and work of scientific and technical bodies on protective measures.—*WPA*



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Section Meetings

Alabama-Mississippi Section: The registration desk opened at 3 PM Oct. 20, in the foyer of the Buena Vista Hotel at Biloxi, Miss. Never before has the registration been so heavy at the very beginning. At 6 PM, the total registered had reached 145. Those still wishing to register were asked to return the following morning, because the Get-Acquainted Hour was scheduled to start at 7.

An outstanding program was enjoyed by all during the 3-day meeting. The Section was favored by having a lady on its program, Mrs. Francis P. Scott, of the Water Works Board of Leeds, Ala., who presented a paper titled "Public Relations From a Cashier's Viewpoint" (*Willing Water* No. 49, December 1957). Papers were presented by people from eight different states. It was estimated that there was 85 per cent attendance at all meetings, including the business session. It was suggested that this was due to the appearance of the secretary at unpredictable times jingling silver dollars and having a drawing for five of them. [A complete list of papers and authors appeared on p. 1605 of the December 1957 issue.]

At a noon luncheon for the ladies on Monday, they were enchanted by the lovely Audrey Stark of New Orleans and her celebrated "Charm School." The Water Dept. of Biloxi entertained the Section Monday evening with a Sea Food Jamboree, and a Jamboree it was. Aprons were placed on everyone prior to entering the dining hall. Some said the shrimp were the best, and others the fried fish, but all agreed that Tip Allen shucked more shrimp than any other member.

The ladies enjoyed their Bingo Party Tuesday morning. A noon luncheon for the Section was arranged, and Karl A. Woltersdorf, of Huntsville, Ala., gave a detailed report on the AWWA program for safety in water utility operation. After the presentation, the group voted unanimously to enter into the safety program. This was the second time that a luncheon was a part of the program, and again it was a success. Tuesday afternoon was reserved for recreational activities, including golf and sightseeing.

The ladies were entertained on Wednesday at their noon luncheon by a girl octet from Gulfpark College. The Club Room on Wednesday was enlivened by the magic tricks of Zaney Blaney, of Houston, Tex. After a most enjoyable banquet Wednesday evening, H. L. Burns was presented with a past-president plaque. William H. Gilmore was nominated for the Fuller Award. It was also announced that, through agreement with the trustee, a new award would be given in the form of a scroll to John L. Snow, of Pensacola, Fla., for his outstanding services to the Section.

C. M. MATHEWS
Secretary-Treasurer

Missouri Section: The regular annual meeting of the Missouri Section was held in St. Louis Sep. 29–Oct. 1, 1957. There was a total registration of approximately 306, which exceeds all past registrations. In addition, there were 44 ladies registered to participate in the activities arranged for them. Ladies' registration more than doubled that of past years.

AWWA Vice-President Finch gave an address on the present problems of

(*Continued on page 78 P&R*)

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Section Meetings

(Continued from page 76 P&R)

achieving sufficient water rates to produce the capital necessary for serving today's increased populations. He also contributed some very pertinent remarks in the discussion of the action of the Missouri State Highway Commission regarding reimbursement of utilities under the revised highway act. [A list of papers presented appeared on p. 1610 of the December 1957 issue.]

At the Annual Banquet, attended by approximately 180 members and guests, Service Citation Awards of the Missouri Section were given to Garvin H. Dyer, manager & chief engineer, Missouri Water Co., Independence; Edward A. Fulton, consulting engineer, St. Louis; Dan R. O'Gorman, St. Louis Water Dept.; and Andrew D. Thain, Water Dept., Neosho. Garvin H. Dyer was nominated to receive the Fuller Award. Life memberships were given to Warren A. Kramer, Div. of Health, Jefferson City, and Otto S. Reynolds, Leadite Co., Kansas City. Elected officers of the Section are: chairman—Robert Hayob, superintendent of public utilities, Marshall; secretary-treasurer—Warren A. Kramer; vice-chairman—J. L. Tuepker Jr., St. Louis County Water Co.

One feature of the meeting which proved of particular interest was a contest consisting of five displays. Contestants were to estimate turbidity and color, identify chemicals, and estimate the flow of water discharged from a pipe orifice. The winner of the contest was Roy Graves of the Anheuser-Busch Co., St. Louis.

WARREN A. KRAMER
Secretary-Treasurer

New Jersey Section: The members of the New Jersey Section journeyed, as has been their practice for many years, to the Madison Hotel at Atlantic City for their annual fall meeting, which was held Oct. 24–26. It was a meeting well attended, despite the flu epidemic, with 336 registered, including 79 ladies. The weather generally was good, with one day of rain to gladden the hearts of the operators (water is badly needed in the state) but not enough to dampen the spirits of the crowd.

Many interesting and informative papers were presented through the efforts of Program Chairman Arthur McConville, who divided the technical sessions into four classifications, presided over as follows: Hunting New Supplies—Harold M. Ohland; Special Water Problems—Martin E. Flentje; Keeping Water Clean—John J. Reager; The Prudent Man—Lewis W. Klockner. [A list of papers and authors appeared on p. 1611 of the December 1957 issue.]

The ladies were welcomed at the showing of a fine film in color, "This is New Jersey," through the courtesy of the New Jersey Bell Telephone Co., and they also were guests of the Association for luncheon at the Smithville Inn, with an interesting bus trip there and back. In lieu of the boardwalk chair ride, which was canceled because of rain, the ladies also enjoyed a tea get-together as guests of the hotel. All was ably managed by the chairman, Mrs. P. S. Wilson.

Nomination for the Fuller Award went to William J. Orchard, a choice loudly applauded by the guests at the Annual Banquet, where Martin E. Flentje, chairman of the Fuller Award Committee, made the announcement. Safety awards were given out by Gordon Linn, chairman of the Safety Committee, to sixteen communities. Jack Faulks was the winner of the membership contest, bringing in seven new members, and Chairman Howard Kitchen of the Membership Committee presented him with a gift certificate for a fine hat. AWWA Vice-President Finch presented a Life Membership Certificate to William V. Jewell, of Jersey City, and an Honorary Membership card to Charles H. Capen. Good food, fine friends, an entertaining comedian, and a

(Continued on page 80 P&R)

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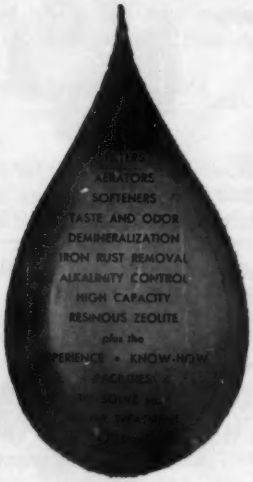

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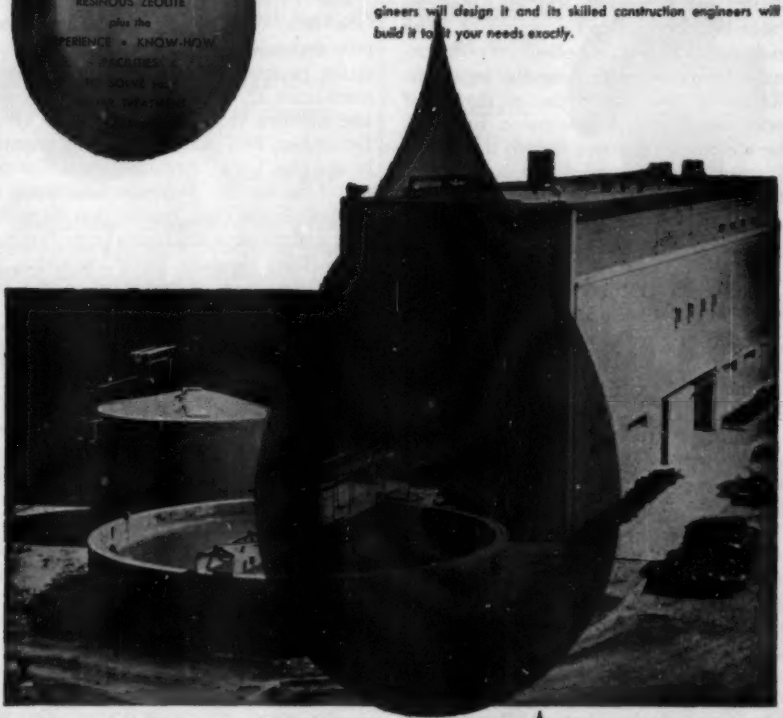

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Section Meetings

(Continued from page 78 P&R)

melodious male quartet all added up to a most enjoyable banquet.

Incoming officers for 1957–58 are: chairman—Martin E. Flentje, Merchantville; vice-chairman—John J. Reager, Perth Amboy; past-chairman—Harold M. Ohland, Jersey City; director—Charles J. Alfke, Weehawken; trustees—Lewis W. Klockner, Trenton, and Peter E. Pallo, New Milford; secretary-treasurer, Albert F. Pleibel, Maplewood. (Pete Pallo replaces Maurice Brunstein, who served 5 years on the Board of Trustees.)

The Saturday morning Operator's Breakfast was, as usual, well attended with hearty appetites for food and knowledge. John H. Murdoch Jr., legal consultant, and Henry A. Riddle, American Water Works Service Co., spoke of "The Prudent Man" and supplied very important information regarding the legal pitfalls in the everyday duties of the water works operator. A discussion followed. The meeting adjourned before noon, and all were well rewarded for having attended.

ALBERT F. PLEIBEL
Secretary-Treasurer

New York Section: At Saranac Inn on Sep. 11–13, 1957, the New York Section held its annual fall meeting. A record attendance of 458 members and their guests had a wonderful time seeing old friends, participating in discussions on the extremely interesting papers which were presented during the technical sessions, playing golf, and dancing to good music.

The technical sessions covered such subjects as hydraulics, hydrant flow tests, control of lawn-sprinkling load, iron and manganese removal, and liquid-alum application. [A list of papers and their authors appeared on p. 1612 of the December 1957 issue.]

A cocktail party sponsored by WSWMA preceded the Annual Banquet, at which President Merryfield was guest speaker. Awards were made to the winners of the golf tournaments organized by Les Hart for Section members and by Liz Hart for their wives. Entertainment after the banquet was highlighted by a dance contest, with champagne prizes to the winners.

KIMBALL BLANCHARD
Secretary-Treasurer

Ohio Section: The Ohio Section held one of its most successful meetings Sep. 18–20, 1957, at the Netherland Hilton Hotel, Cincinnati. A near-record attendance was registered, with a total of 339, including 58 ladies.

The Program Committee, with H. C. Growdon of Portsmouth as chairman, provided a very well balanced and interesting program, as evidenced by the large attendance at sessions. [A list of papers and authors appeared on p. 1613 of the December 1957 issue.] Special mention is due the Local Arrangements Committee, Charles M. Bolton, chairman; the Ladies' Committee, headed by Mrs. Bolton; and the manufacturers' entertainment committee, Howard Bass, chairman, for their important contribution to the success of the meeting.

Registration was formally opened Wednesday morning and was very capably handled by the Cincinnati Convention Bureau under the supervision of Dan Laurence, superintendent, Commercial Div., Cincinnati Water Works. The sessions started Wednesday afternoon, following the invocation by Rev. Rolland W. Keebler and the address of welcome by Charles P. Taft, mayor of Cincinnati. Technical sessions continued on Thursday and concluded Friday noon. The presiding officers for the four sessions were H. C. Growdon, Portsmouth; S. D. Bresler, Lima; A. A. Ulrich, Massillon; and Frank Ruck, Troy.

The social activities opened Thursday evening with WSWMA as host for a

(Continued on page 84 P&R)

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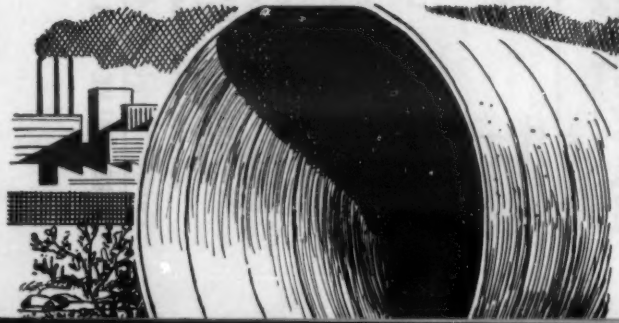

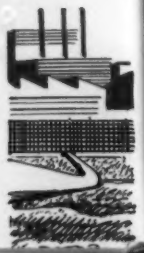

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Section Meetings

(Continued from page 80 P&R)

very enjoyable cocktail hour. This was immediately followed by the annual banquet, with approximately 300 attending. Guests of honor were Mayor Taft, City Manager C. A. Harrell and Mrs. Harrell, Judge Carl W. Rich, and Reverend and Mrs. Keebler. Vice-President Finch presented Life Membership certificates to Frank E. deMartini, Cincinnati; Edmund B. Evans, Kettering; and Homer Knox, Columbus. LaDue citations went to Harold H. Mace, Cincinnati; John A. Marsh, Euclid; and S. L. Tolman, Columbus. The Fuller Award Committee nominated Raymond H. Fuller, of Columbus. Judge Rich talked on the history of Cincinnati, and the entertainment was concluded with the showing of a film, "Water and Wild Life in Ohio," narrated by naturalist Karl Maslowski.

The ladies' program started with a get-acquainted tea on Wednesday afternoon. On Thursday the ladies' luncheon was held in the Skyline Room of the Terrace Hilton Hotel. In the afternoon a sightseeing trip around old Cincinnati proved very interesting.

The annual business meeting and election of officers took place Friday morning, presided over by Chairman M. W. Tatlock. The new officers elected were: chairman—H. C. Growdon, Portsmouth; vice-chairman—S. D. Bresler, Lima; trustee—Richard Deem, Chillicothe; and secretary-treasurer—M. E. Druley, Wilmington.

Inspection trips to the Cincinnati Water Filtration Plant and the Taft Sanitary Engineering Center brought the meeting to a close Friday afternoon.

M. E. DRULEY
Secretary-Treasurer

Wisconsin Section: The Wisconsin Section held its 36th annual meeting in Milwaukee at the Hotel Schroeder Sep. 4–6, 1957. The registration, totaling 340 (175 members and guests, 76 manufacturers' representatives, and 89 ladies), was a record high exceeding by 24 the previous high set at Green Bay in 1954. Particularly gratifying was the excellent attendance at the technical sessions. [A list of papers presented appeared on p. 1616 of the December 1957 issue.]

Officers elected for the ensuing year are: chairman—Harvey E. Wirth, Madison; vice-chairman—Arthur J. Jark, Jefferson; secretary-treasurer—Harry Breimeister, Milwaukee; director—O. J. Muegge, Madison; trustee—Philip S. Davy, La Crosse; trustee ex officio—Past-Chairman James E. Kerslake, Milwaukee. The Section's nominee for the Fuller Award was Dr. M. Starr Nichols, assistant director of the State Laboratory of Hygiene, Madison.

Registration began on Wednesday morning, Sep. 4, the technical sessions starting on the afternoon of the same day and continuing until noon Friday. Each session opened with an interesting half-hour color film which attracted a good audience for the technical discussions that followed immediately. The membership was also enthusiastic over the 15-min breaks at 10:30 AM on Thursday and Friday mornings, at which coffee and pastries were served gratis.

The annual banquet on Thursday evening was attended by 287 persons, a record high for the Section. An excellent dinner of Cornish hens, the low strains of soothing music, and an entertaining floor show contributed to a delightful evening.

The ladies' program, which attracted 89 women, included a theater showing of "Around the World in 80 Days" on Wednesday afternoon and a cocktail party, luncheon, and cards on Thursday afternoon. A coffee hour each morning in the Ladies Headquarters Room at the Hotel Schroeder provided an ideal setting for making and renewing acquaintances.

HARRY BREIMEISTER
Secretary-Treasurer

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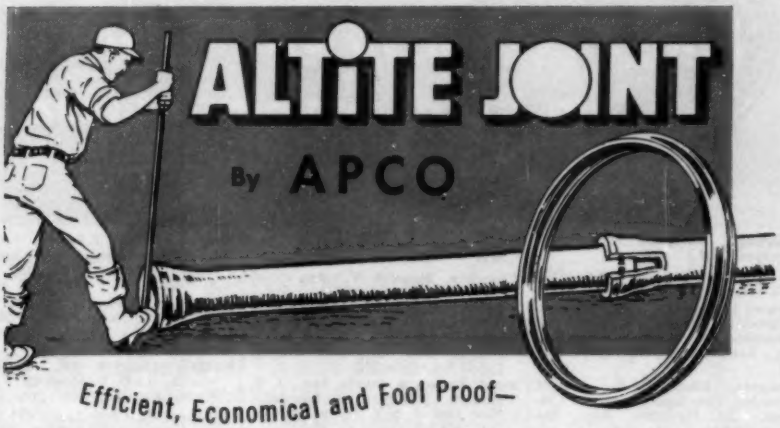

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Alldredge, Harold; *see* Mount Prospect (Ill.)

Austin, L. P.; *see* Four Oaks (N.C.)

Barnes, George B., Assoc. Research Chemist, Citus Sermi Research & Development Co., 916 Clarence St., Lake Charles, La. (Jan. '58) *R*

Blodgett, Charles O., Science Teacher, San Luis Obispo Jr. College, 529 Hathaway Ave., San Luis Obispo, Calif. (Jan. '58)

Bower, Blair T.; *see* Delaware River Basin Advisory Committee

Boyd, Kenneth R., Gen. Foreman, Water Dept., 425 Mason St., San Francisco, Calif. (Oct. '57) *MD*

Brown, Robert Daniel, Civ. Engr., Conti Contractors, 11 Brantwood Dr., Summit, N.J. (Jan. '58) *D*

Brown, W. D., Supt., Town Utilities, Sequim, Wash. (Oct. '57) *M*

Caldwell, James L., Supt., El Dorado Water Corp., El Dorado, Ark. (Jan. '58) *PD*

Calhoun, Otis Truman, Director of Public Works, 134 Hillside Blvd., Daly City, Calif. (Jan. '58) *MPD*

Chan, Jose Agustin, San. Engr., Oficina Nacional de Urbanismo, Managua, Nicaragua (Oct. '57) *MD*

Chediak, Ana Barquet, Chief, Dept. of Bromatology, Instituto Nacional de Higiene, Havana, Cuba (Jan. '57)

Chisholm, Joseph, Supt. of Works, Antigonish, N.S. (Jan. '58)

Cole, Sidney A., Div. Mgr., Wallace & Tiernan Inc., 25 Main St., Belleville 9, N.J. (Oct. '57) *RP*

Conover, Joseph M., Supt., Water Dept., Monroe Township, Williamstown, N.J. (Jan. '58) *M*

Crawford, Charles E., Mgr., Water Dept., Box 158, Flora, Ind. (Jan. '58)

Davis, Dale V., Partner, Davis & Razak, Box 897, Dodge City, Kan. (Oct. '57) *RD*

Delaware River Basin Advisory Committee, Blair T. Bower, Water Resources Engr., 930 Suburban Station Bldg., Philadelphia 3, Pa. (Corp. M. Oct. '57) *RPD*

Del Campo C., Nicanor, Pres., Hydraulic Company of Florida, Avenida 39A, 4410 Entre, Marianao, Havana, Cuba (Oct. '57) *MR*

Dobrin, Saxe, Cons., 6602 Ampere Ave., North Hollywood, Calif. (Oct. '57) *MR*

Driskill, Buford L., Jr., Salesman, Lynchburg Foundry Co., 620 Court St., Lynchburg, Va. (Jan. '58) *RD*

Duffey, Minor C., Supt. of Water, Clearwater, Fla. (Oct. '57) *PD*

Duncan, William F., Owner, Duncan & Assocs., Box 48, Bradfordwoods, Pa. (Jan. '58) *RPD*

Farley, Roy N., Supt., West Virginia Water Service Co., 100 Scott St., Princeton, W.Va. (Oct. '57) *MD*

Florence, Harold V., Jr., Chief Water Treatment Oper., Water Dept., Maple Ave., Ridgewood, N.J. (Jan. '58) *MP*

Foland, Donald L., Water Engr., 308 E. Berry St., Fort Wayne, Ind. (Jan. '58) *MD*

Ford, Bacon & Davis, Inc., J. B. Howlett, Librarian, 39 Broadway, New York 6, N.Y. (Corp. M. Jan. '58) *MRPD*

Four Oaks, Town of, L. P. Austin, Mayor, Four Oaks, N.C. (Corp. M. Oct. '57)

Gassman, Walter F., Assoc. Engr., Eng. Office of Clyde G. Kennedy, 604 Mission St., San Francisco, Calif. (Oct. '57) *MRPD*

Green, Claude G., Supervisor, Water Dept., City Hall, Grants Pass, Ore. (Jan. '58) *MD*

Gustafson, J. S., Pres., Infilco, Inc., Box 5033, Tucson, Ariz. (Jan. '58) *P*

Harris, William E., Sales Engr., Sparling Meter Co., 66 Luckie St., N.W., Atlanta 3, Ga. (Jan. '58) *D*

Harshbarger, John W., Dist. Geologist, Ground Water Branch, US Geological Survey, Box 2270, Tucson, Ariz. (Oct. '57)

Hausman, Forrest Henry, Water Supt., 300 W. Lakeshore, Storm Lake, Iowa (Jan. '58) *MRPD*

Hawthorne, John A., Asst. Secy., Hamlin & Co., Brokers, Inc., 52 Broadway, New York 4, N.Y. (Jan. '58) *RD*

Heath, Harlan Howard, Sr. Hydr. Engr., Creegan & D'Angelo, Box 248, Saratoga, Calif. (Jan. '58) *RPD*

Hess, Raymond W., Exec. Consultant, Water Dept., Hamburg, N.Y. (Oct. '57) *MRPD*

Hill, Richard F., Dist. Engr., State Bd. of Health, McIntyre Bldg., Asheville, N.C. (Oct. '57) *MP*

Hinton, Robert A., Maint. Mechanic, Metropolitan Water Dist. of Southern Calif., 306 W. 3rd St., Los Angeles, Calif. (Oct. '57) *MRPD*

Hollingshad, William R., Chief Chemist, Deady Chem. Co., 1401 Fairfax Trafficway, Kansas City 15, Kan. (Jan. '58) *PD*

Hooper, Walter Henry Wilbur, Mgr., Fletcher Chem. Co. (Aust.) PTY Ltd., Somerville Rd., West Footscray, Victoria, Australia (Jan. '58)

Howlett, J. B.; *see* Ford, Bacon & Davis, Inc.

Huiszoon, Cornelis J., Asst. to Water Supply Engr., Southern Calif. Water Co., 11911 S. Vermont Ave., Los Angeles, Calif. (Oct. '57) *RPD*

Humphreys, Cyrus Henry, Water Supt., 501 Ave. G, Levelland, Tex. (Jan. '58) *MD*

Hurst, Howard M., San Engr., Waterworks Equipment Co., 502 W. 3rd St., Salt Lake City 10, Utah (Oct. '57) *RPD*

Jacob, Charles Edward, Groundwater Consultant, 9214 Yolanda Ave., Northridge, Calif. (Oct. '57) *R*

Jamerson, Robert Harry, Suburban Water Systems, 16340 Maplegrove St., La Puente, Calif. (Oct. '57) *P*

Keller, Charles W., Black & Veatch, 1500 Meadowlake Pkwy., Kansas City 14, Mo. (Jan. '57)

Klassen, J., Cons. Engr., 454 Slater St., Ottawa 4, Ont. (Jan. '58)

Kreckman, Robert C., Water Eng. Asst., 308 E. Berry St., Fort Wayne, Ind. (Jan. '58) *MD*

Lambert, D. E., Supt., Water Works, 1604 Main St., Elwood, Ind. (Oct. '57) *MRD*

Lingham, Carlton W., Hydr. Engr., Surface Water Branch, US Geological Survey, Box 3327, University Station, Charlottesville, Va. (Oct. '57) *R*

Lord, James W., Town Mgr., Coeburn, Va. (Oct. '57)

Losee, Louis B., Water Consultant, Eng. Dept., E. I. duPont de Nemours & Co., Inc., Wilmington 98, Del. (Oct. '57) *RP*

MacAleer, Lee, Indus. & Munic. Sales, Keasbey & Mattison Co., Ambler, Pa. (Oct. '57) *D*

MacGowan, D. F., Inspector, New Brunswick Bd. of Underwriters, Fire Protection Dept., 22 King St., Saint John, N.B. (Oct. '57)

MacRitchie, Norman, Chief Engr., A. C. LoPrest Co., 551 Minna, San Francisco, Calif. (Oct. '57) *RP*

Marston, Arnold M., Engr., United Concrete Pipe Corp., Box 218, Pleasant Grove, Utah (Oct. '57) *PD*

McCall, J. B., Vice-Pres., Searles Domestic Water Co., Box 364, Trona, Calif. (Oct. '57) *MRD*

McCarty, Perry Lee, Graduate Student in San. Eng., Massachusetts Inst. of Technology, Cambridge, Mass. (Jr. M. Oct. '57)

McIntire, Robert Lellon, Waterworks Supt., Fountain City, Ind. (Oct. '57)

McKendrick, Maurice N., Sales Engr., Waterworks Equipment Co., Box 236, Salt Lake City, Utah (Oct. '57) *PD*

(Continued on page 88 P&R)

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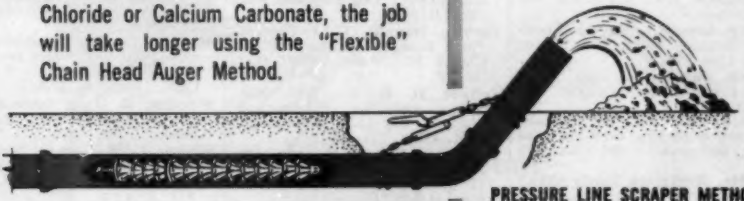

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(Continued from page 86 P&R)

McKiernan, Robert, Chemist, City Utilities, 576 Park Ave., Barberton, Ohio (Oct. '57) *RPD*

McKinty, Dennis, Waterworks Supt., 69 Young St., S., Sudbury, Ont. (Oct. '57)

McMahan, Richard A., Engr., Moye Constr. Co., Deland, Fla. (Jan. '58) *MRPD*

Mohanrao, G. J., Research Asst., Dept. of Civ. & San. Eng., Room 1-083, Massachusetts Inst. of Technology, Cambridge 39, Mass. (Jr. M. Jan. '57)

Moser, George Allen, Sales Repr., General Chemical Div., Box 970, Charlotte, N.C. (Oct. '57)

Mount Prospect, Village of, Harold Alldredge, Water Supt., 112 E. Northwest Hghy., Mount Prospect, Ill. (Corp. M. Jan. '58) *MRD*

O'Connor, Charles, Water & Street Supt., Inverness Town, N.S. (Jan. '58)

Ott, Robert J., Sales Repr., Mueller Co., Decatur, Ill. (Oct. '57) *D*

Owens, Marion Rupert, Draftsman, Water Works, Greenville, S.C. (Jan. '58)

Parsons, William Andrews, Assoc. Prof. of San. Eng., Virginia Polytechnic Inst., Blacksburg, Va. (Oct. '57) *P*

Patrick, Glen R., Analytical Chemist, Filtration Plant, Fort Wayne, Ind. (Jan. '58) *P*

Patrick, Joe Peeler, Cons. Engr., Box 156, Roebuck, S.C. (Oct. '57) *RPD*

Purdom, William D., Partner, Purdom & Jeschka, 2415 Maryland Ave., Baltimore 18, Md. (Oct. '57) *PD*

Roberts, Bert; *see* Toledo (Ore.)

Robinson, Giles L., Civ. Engr., 65 McCall Ave., Memphis, Tenn. (Oct. '57) *MRPD*

Robinson, Thomas M., Supt., Munic. Water & Gas Admin., Vicksburg, Miss. (Oct. '57)

Rogers, Claude P., Asst. Water Supt., 237 W. Commonwealth Ave., Fullerton, Calif. (Jan. '58) *MD*

Roy, Ramendra Narayan Kar, Sr. Chem. Engr., Paterson Eng. Co., 21 Theatre Rd., Calcutta 16, India (Oct. '57) *P*

Royer, Jack L., Asst. Water Supt., 237 W. Commonwealth Ave., Fullerton, Calif. (Jan. '58) *MD*

Russelmann, Heinz B., Dist. State San. Engr., State Dept. of Health, 18 S. Market St., Johnstown, N.Y. (Jan. '58) *RP*

St. Michel, Leo Alfred, Engr., K. B. MacKichan & Assocs., 211 N. 5th St., Grand Forks, N.D. (Oct. '57) *PD*

Salasse, Hassan, Jr. Engr., Southern Calif. Water Co., 11911 S. Vermont, Los Angeles 44, Calif. (Oct. '57) *MRPD*

Sanders, Walter McDonald, San. Engr. Cons., US Operations Mission to Brazil, I.C.A., APO 676, USOM-BH, New York, N.Y. (Oct. '57) *MP*

Scalf, R. D., Chief Operator, Dist. No. 1, Kenton County Water Com., 31 E. 17th St., Covington, Ky. (Oct. '57) *P*

Shelburn, Ralph, Clyde E. Williams & Assocs., 5528 S. Main St., Anderson, Ind. (Oct. '56)

Simon, Morton S., Chief Engr., Muncie Water Works Co., 209 N. Walnut St., Muncie, Ind. (Oct. '57) *P*

Sizemore, William Franklin, Supt., Water Works, N. 1st St., Van Buren, Ind. (Oct. '57) *MPD*

Slusser, James K., Dist. Repr., Climax Engine Mfg. Co., 208 S. LaSalle St., Chicago 4, Ill. (Oct. '57) *MD*

Smith, Dan Richard, Chief, Bureau of Admin. Services, Dept. of Public Works, Baltimore County, Towson 4, Md. (Oct. '57) *M*

Smith, Eugene Woods, Design Engr., Water Works, 2015 Commerce, Dallas 1, Tex. (Oct. '57) *MD*

Smith, Hamilton D., Supt., Granite City Div., E. St. Louis & Interurban Water Co., 1837 Delmar Ave., Granite City, Ill. (Oct '57) *M*

Smith, L. R., Vice-Pres., Boyce Co., Inc., 504 Pennsylvania Ave., Clearwater, Fla. (Oct. '57) *D*

Smith, Roberta C., Asst. Clerk, Water Dept., East Liverpool, Ohio (Oct. '57) *M*

Tarvin, Donald, Chief Chemist., Floyd Browne & Assocs., 125 W. Church St., Marion, Ohio (Oct. '57) *P*

Tellyer, H. B., Jr., Dist. Mgr., Tellyer Pipe Div. of American-Marietta, Box 1629, Albuquerque, N.M. (Oct. '57) *RD*

Thomann, Robert V., Asst. San. Engr., US Public Health Service, 42 Broadway, New York, N.Y. (Oct. '57) *RPD*

Tighe, Frank Howard, Jr., Mech. Engr., John E. Harms, Jr. & Assocs., 8 Crain Highway, N.W., Glen Burnie, Md. (Oct. '57) *P*

Toledo, City of, Bert Roberts, Water Supt., City Hall, Toledo, Ore. (Corp. M. Oct. '57) *RD*

Toups, John M., Dist. Engr., Orange County Water Dist., 941 E. 1st St., Santa Ana, Calif. (Oct. '57) *RD*

Townshend, Allan Robert, San. Engr., R. V. Anderson & Assocs., 194 Wilson Ave., Toronto, Ont. (Oct. '57)

Tribble, Hiram L., Civ. Engr., Tribble & Assocs., Inc., Box 2103, Macon, Ga. (Oct. '57) *RPD*

Troutt, Gilbert, Chemist, Wallace & Tiernan, Inc., Box 8634, Oklahoma City, Okla. (Oct. '57) *RPD*

Turner, James H., Gen. Mgr., Water Dept., 425 Mason St., San Francisco, Calif. (Oct. '57)

Turney, William G., Cons. Engr., Michigan Assocs., 221 N. Cedar St., Lansing, Mich. (Oct. '57) *RPD*

Tyler, George, Burney County Water Dist., Burney, Calif. (Oct. '57) *MPD*

Uhrig, Carl Henry, Sr., Land Surveyor, John E. Harms, Jr. & Assocs., 8 Crain Highway, N.W., Glen Burnie, Md. (Oct. '57) *D*

US Naval Proving Ground, Director, Maint. Control Div., Public Works Dept., Dahlgren, Va. (Munic. Sv. Sub. Oct. '57)

Van Brocklin, Finley G., Sales Engr., Allen-Shuff Corp., 166 Monroe Ave., Memphis 3, Tenn. (Oct. '57) *MRPD*

Vance, Russell Lee, Owner, Culligan Water Conditioning Service, 5408 Florida Ave., Tampa, Fla. (Oct. '57) *P*

Van Reuth, Arthur Geatty, Pres., Van Reuth & Weidner, Inc., 411 Tunbridge Rd., Baltimore 12, Md. (Oct. '57) *RP*

Vianna, Newton dos Santas, Engr., Water Dept., City Hall, Bello Horizonte, M. G., Brasil (Oct. '57) *MPD*

Walden Bd. of Water Comrs., Fred Wood, Chairman, Box 72, Walden, N.Y. (Munic. Sv. Sub. Oct. '57) *D*

Ward, John A., Cons. Engr., 1420 Spring Lane, Salt Lake City 17, Utah (Oct. '57) *R*

Wells, J. Arthur, Owner, Apex Eng. & Sales, 1485 Bayshore Blvd., San Francisco, Calif. (Oct. '57)

Wernle, Arthur John, Civ. Engr., Leo A. Daly Co., 1726 Ambassador Bldg., St. Louis 1, Mo. (Oct. '57) *RPD*

Wheeler, Howard Baldwin, Assoc. Civ. Engr., Water Dept., 237 W. Commonwealth, Fullerton, Calif. (Jan. '58) *MD*

Wheeler, R. Dale, Salesman, Wallace & Tiernan, Inc., Box 833, Lubbock, Tex. (Oct. '57) *P*

White, J. W., Armco Drainage & Metal Products of Canada Ltd., Box 690, Sackville, N.B. (Oct. '57)

Whitten, Ray Lloyd, Supt., Munic. Waterworks, Mineral Springs, Ark. (Oct. '57)

Williams, Robert L., Chemist, Dalecarlia Filtration Plant, 5900 MacArthur Blvd., N.W., Washington, D.C. (Oct. '57) *P*

Wilson, Hollis, Calif. Distr., Wilson Engine & Equipment Co., 2350 E. Spring St., Long Beach, Calif. (Oct. '57) *MD*

Wilson, James W., Engr., State Dept. of Health, Austin, Tex. (Oct. '57) *RPD*

Winsemann, William H., Jr., Project Mgr., Harbert Const. Corp., 2208—8th Ave., S., Birmingham, Ala. (Oct. '57) *PD*

Wood, Fred; *see* Walden (N.Y.) Bd. of Water Comrs.

Wraight, Frank Donald, San. Engr., State Bd. of Health, 1330 W. Michigan, Indianapolis 7, Ind. (Oct. '57) *MP*

Wright, Charles V., Jr., San. Engr., US Public Health Service, Washington, D.C. (Oct. '57) *RP*

Wright, Robert S., City Engr., City Hall, Columbia, Tenn. (Oct. '57) *RD*

Wuerth, Howard, City Mgr., Valentine, Neb. (Oct. '57) *MR*

Yackey, George F., Gen. Mgr., Public Utility Dist., Box 427, Fallbrook, Calif. (Oct. '57) *MRPD*

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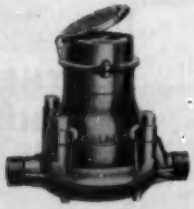

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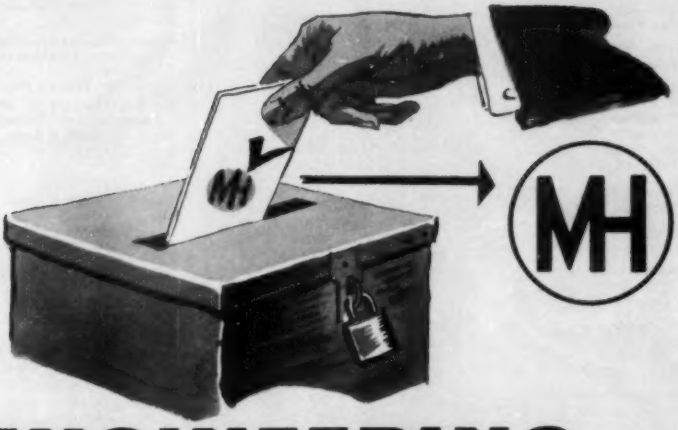

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Years of experience with water problems of all kinds in every part of the country are available to you. A phone call or letter will put Calgon's technical know-how to work on your problem.

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Graver Tank & Mfg. Co.
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Stops, Curb and Corporation:
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Mueller Co.

Storage Tanks: see Tanks

Strainers, Suction:
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M. Greenberg's Sons
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Omega Machine Co. (Div., B-I-F Industries, Inc.)
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Chicago Bridge & Iron Co.
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Graver Tank & Mfg. Co.
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Tapping-Drilling Machines:
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Tapping Machines, Corp.:
Hays Mfg. Co.
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General Filter Co.
Graver Water Conditioning Co.
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DeLaval Steam Turbine Co.

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M & H Valve & Fittings Co.
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W. S. Rockwell Co.
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Valves, Detector Check:
Hersey Mfg. Co.

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Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
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Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.

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Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
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Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
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A. P. Smith Mfg. Co.
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Darling Valve & Mfg. Co.
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Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.
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Valves, Swing Check:
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Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
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M & H Valve & Fittings Co.
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Zeolite: see Ion Exchange Materials

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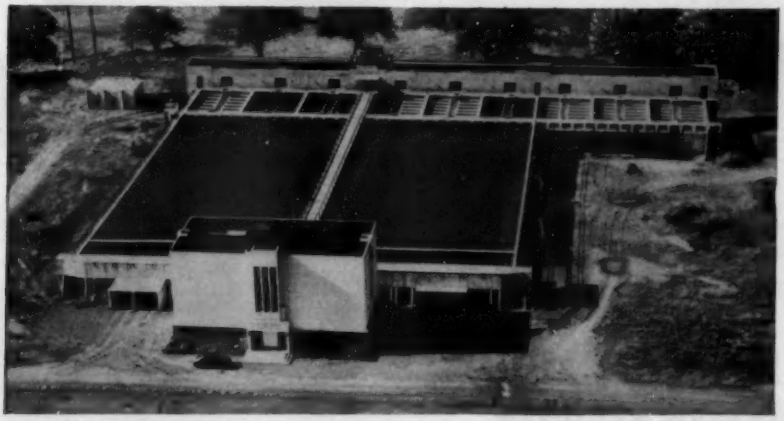

Ramuc® Mildew-Resistant Enamel guards 250-foot-long tunnel connecting headhouse with pumping section. Flanked on either side by one million gallons of cold water in twin reservoirs, the warmer tunnel is subject to heavy condensation and dripping. Tunnel is but one of many Inertol-protected areas of this plant.

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The largest municipal water filtration plant in the Pacific Northwest, the 37.5-MGD Hayden Bridge installation serves over 60,000 persons in the fast-growing Eugene metropolitan area.

Inertol coatings, specified for this plant by Consulting Engineers Stevens & Thompson, Portland, provide attractive, cost-cutting protection . . . safeguard surfaces against condensation, mildew, abrasion, submersion and weather.

Specifications for Ramuc Mildew-Resistant Enamel

A glossy, mildew-resistant, chlorinated natural rubber-base coating, in color, for non-submerged concrete, steel and indoor wood surfaces.

Concrete Surfaces: *Colors:* color chart 560. *No. of coats:* one coat *Ramuc* Mildew-Resistant Enamel over two coats *Ramuc* Undercoater. For flat finish, two coats *Ramuc* Mildew-Resistant Flat to bare masonry—omit undercoater. *Coverage:* 250 sq. ft. per gal. per coat. *Approximate mil thickness per coat:* 1.2. *Drying Time:* 24 hours. *Primer: Ramuc* Mildew-Resistant Undercoater (2 coats). *Thinners: Inertol* Thinner 2000-A for brushing; 2000 for spraying. *Application:* Brushing: *Ramuc* Mildew-Resistant Enamel—brush type, as furnished. Spraying: *Ramuc* Mildew-Resistant Enamel—spray type, add sufficient Thinner 2000 for proper atomization.

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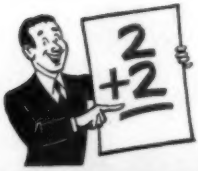

The solution to this problem is always the same . . . but

Water Treatment Problems are different

No two water treatment problems are exactly alike. The right solution to each can only be arrived at after a careful study of the local conditions. Variables such as raw water composition, rate of flow and results required automatically rule out the cure-all approach. The installation shown below is a good example of how equipment should be selected to fit the job . . . and not vice versa.

Aerial view of new 36 MGD North County Water Plant, St. Louis, Missouri.
Contractor: Woerman Construction Co., St. Louis, Mo.

St. Louis County, Missouri

New 36 MGD North County Plant Designed and Constructed in Less than 11 Months

One of the three water purification plants operated by the St. Louis County Water Company, the North County Plant began operation in 1955. Designed for a capacity of 36 MGD, this plant was designed and constructed in less than eleven months. The plant is located on the South bank of the Missouri River because of favorable river channel conditions for intake operation and because it would be possible to protect the plant against maximum river floods.

In the flowsheet at the North County Plant a 130′ dia. Dorr Heavy-Duty Torq Clarifier serves as the pre-sedimentation basin. This basin, which holds 4,300,000 gallons, provides a detention time of approximately 2½ hours. Four Dorrco Squarex Clarifiers, each 145′ sq., comprise the primary and secondary settling zones.

If you would like more information on the complete line of Dorr-Oliver Water Treatment Equipment, write for Bulletin No. 9141, Dorr-Oliver Incorporated, Stamford, Connecticut.

Every day over 8½ billion gallons of water are treated by Dorr-Oliver equipment.

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Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
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